COLONY AND PROTECTORATE OF KENYA

DEPARTMENT OF AGRICULTURE ANNUAL REPORT 1954

Vol. II.—Record of Investigations

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Vol. II.—Record of Investigations

THE MINISTER FOR AGRICULTURE, ANIMAL HUSBANDRY
AND WATER RESOURCES, NAIROBI

SIR,

I have the honour to transmit herewith Volume II of the Annual Report of this Department for the year 1954. This volume is a record of investigational work carried out during the year and contains the reports of all research and specialist officers on work which has reached a stage which warrants publication of the results. A summary of results of the main lines of work of each section has already been published in Volume I of this Department's Annual Report for 1954.

I have the honour to be,
Sir,
Your obedient servant,

G. M. RODDAN,
Director of Agriculture.

28th June, 1955.

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ANNUAL REPORT OF THE SENIOR ENTOMOLOGIST, 1954

Plant Protection

Importation of Plants

Although the number of plant importation permits issued was a considerable increase on the previous year, nevertheless the amount of plant material imported without permit was still large. A percentage of the public still appears to be unaware of the conditions under which plant material may be accepted into Kenya, this in spite of much publicity given in the Press and otherwise from time to time over a considerable number of years. Application for importation permits and the compliance by the exporting countries with the conditions stated thereon lessen to a great extent the work of the section and would be a decided advantage to the importer in decreasing delays in delivery, unnecessary correspondence and sometimes destruction of material.

Plant importation permits issued during the year totalled 1,409. The number of parcels imported through the Post Office and inspected at the Scott Agricultural Laboratories amounted to 2,601, and in addition 85 parcels by air freight were also inspected. Plant material is often brought into the country in personal baggage which necessitates inspection and treatment. Three hundred and forty-seven consignments were subjected to fumigation. One hundred and fifty-eight consignments were intercepted as being in some way irregular, most of which were released after examination and treatment, but a small number were either re-exported or destroyed. Fines collected amounted to Sh. 438.

Arrangments were made for the importation through the Quarantine Station of E.A.A.F.R.O. at Muguga of limited quantities of certain plants hitherto prohibited. These include Chrysanthemums, Dahlias, Begonias and Arum Lilies.

The number of consignments of plants examined for plant health certificates was 463. A considerable number of these were fumigated, either because of pest infestation, or as demanded by the country of destination.

Insects Intercepted

	From	*On*
Lepidoptera—		
Blastobasis sp.	Tanganyika	Tea seed
Rhynchota—		
Coccidae:		
Parlatoria pergandei Comst.	Israel	Oranges
Saissetia hemisphaerica (T.T.)	Holland	Ferns
Coleoptera—		
Curculionidae:		
Isanates irregularis Fst. ..	Tanganyika	Tea seed
Pomphus sp.	Southern Rhodesia	Hibiscus seed
Diptera—		
Trypetidae	Southern Rhodesia	Melons
Thysanoptera—		
Unidentified	England	Strawberry plants
Taeniothrips nigricornis (Schmutz)	India	Cut flowers
Thrips hawaiiensis .. (Morgan)	India	Cut flowers
Thrips ficrum (Schmutz)	India	Cut flowers

It will be noted from the statistics given in this report that the work of implementing the Plant Protection Ordinance increases annually. This is reflected by the fact that in 1946 only 439 plant importation permits were issued as against 1,409 during the current year.

Thanks are recorded to the Senior Plant Pathologist and the Chief Grader and Inspector and their staffs for their help and co-operation throughout the year.

Stored Products

Miss J. Slow reports on experimental work as follows:—

"Insecticidal Resins

An experiment to determine the efficacy of three urea formaldehyde insecticidal resins, D.D.T. wettable powder, and B.H.C. wettable powder as a treatment for the walls of a store was set up in May. The sprays used were as follows:—

(1) D.D.T. wettable powder in 1 per cent dilution.

(2) B.H.C. wettable powder in 1 per cent dilution.

(3) Urea formaldehyde resin containing 5 per cent Aldrin, 10 per cent Dieldrin.

(4) Urea formaldehyde resin containing 2 per cent B.H.C., 20 per cent D.D.T.

(5) Urea formaldehyde resin containing 5 per cent B.H.C., 10 per cent D.D.T.

All the above used at 2 gal. to 1,000 sq. ft.

The sprays were applied to the walls of a maize store, and tested at intervals by placing live insects on treated areas. Results after six months were as follows:—

(*a*) D.D.T. and B.H.C. wettable powders were virtually ineffective after three months.

(*b*) The resin containing Aldrin and Dieldrin lost its effectiveness after three months.

(*c*) The effectiveness of the resin containing 5 per cent B.H.C. and 10 per cent D.D.T. began to decline after six months.

(*d*) The resin containing 2 per cent B.H.C. and 20 per cent D.D.T. was fully effective up to at least six months against *Calandra* and *Tribolium*. It is also effective against *Oryzaephilus*.

The experiment is still continuing. It may be remarked that the conditions are a severe test of any insecticides as there is a good deal of dust in the store from time to time.

Pyrethrum/Piperonyl Butoxide Experiment in Bags

This experiment, set up in September, 1953, consisted of 200-lb. bags of maize treated as follows:—

(1) Untreated bags.

(2) Piperonyl butoxide at 6 oz. to the bag.

(3) Pyrethrum powder at 7.7 oz. to the bag, 25 parts per million.

(4) Insecticide containing 0.1 per cent pyrethrins and 1.6 per cent piperonyl butoxide at 6 oz. to the bag.

(5) Insecticide as in (4) at 12 oz. to the bag.

There were four replicates of each treatment and sampling went on until December, 1954. The populations of live weevils in the untreated bags and in treatment (2) listed above rose fairly steadily, which confirms that piperonyl butoxide by itself has no insecticidal properties. Treatment (3) gave good control up to six months, treatment (4) up to about seven months, while treatment (5) was still effective at 15 months when the experiment was discontinued. At this stage the untreated grain weighed only just over half as much as that of treatment (5), the latter being in almost sound condition. It is also noteworthy that the bags of treatment (5) contained practically no secondary pests, while these were present in considerable numbers in untreated bags.

Insecticidal Treatment of Bag Fabric

In this experiment, set up in March, 1954, 12 bags of which the fabric had been impregnated with pyrethrum-piperonyl butoxide were filled with maize, fumigated with methyl bromide and built into a stack four bags long and three high. A second stack of 12 untreated bags of fumigated maize was built separately.

Samples were taken from end to end of each bag with a long sampling spear, and the approximate numbers of live insects per bag calculated. Sampling was continued at intervals until September, when examination of the figures showed little difference between the treated and untreated bags. The treated bags afforded negligible protection against *Calandra* and *Tribolium* in the conditions of the experiment.

Experiment to Determine Insecticide Residues after Stack Treatment

Two experimental stacks of 100 bags each were built in the Maize Control store at the Scott Laboratories in December. One stack had each layer heavily dusted with 1 per cent lindane in kaolin, and the other was sprayed after the stack was built with D.D.T. wettable powder in $2\frac{1}{2}$ per cent dilution.

After a month samples were taken from each stack, and were analysed by kind co-operation of Colonial Insecticide Research Unit, Arusha, to determine whether these treatments left residues above the approved limits.

Advisory Work

In view of reported heavy infestations of *Tribolium* and *Oryzaephilus* many stores were visited and examined. It was considered that good results could be obtained by spraying the fabric of stores with a mixture of D.D.T. and B.H.C., especially between crops, when the store is empty, and storekeepers were advised to do this. At Meru, where maize is already heavily infested before it reaches the Maize Control store, it appeard that the traders' stores were at fault, and that these should in future be cleaned out and sprayed before the market opened."

Mr. Kockum reports as follows:—

"Crib Experiments

The results from the 1953 crib experiments were computed and statistically analysed. A paper will be published on this together with the 1954 experiments which had not been completed by the end of the year. Dusting the exposed cobs on the sidewalls of an open crib with pyrethrum powder and dye-treated pyrethrum powder gave no protection against insects nor any protection when the treatments were repeated.

Dust treatment of the whole crib with 0.04 per cent gamma B.H.C. at a rate of 8 oz. per 9 cu. ft. and 0.08 per cent B.H.C. at a rate of 4 oz. per 9 cu. ft. (one part gamma B.H.C. to a million of grain) gave equal results, namely a good, but not complete protection inside the bulk. The treatments had, however, only a small protective effect on the maize on exposed sides of the crib. Seven times the concentration of gamma B.H.C. per cu. ft. in 4 oz. of dust gave complete protection, and 3.5 times the concentration gave also a very good protection inside the bulk, but only fair protection on the outside. The present recommendation of 8 oz. 0.5 per cent gamma B.H.C. dust per 9 cu. ft. is shown to be excessive since half the rate under experimental conditions when the dusting is carried out evenly and carefully, is fully effective. Under practical conditions on the farms the dust is rarely if ever so carefully applied. European farmers and maize graders have testified that the result of last year's treatment was extremely good. It was found that many farmers had used less than the recommended rate and a number had not used any treatment at all.

A heavy reinfestation of clean maize occurs on the railway. An average empty truck in Nairobi was treated with wettable D.D.T. and the insects were collected over a number of days. This truck harboured a population of 60,000 insects."

General Insecticide Work

Mr. P. T. Walker, an officer of the Colonial Insecticide Research Unit completed his work at the Scott Agricultural Laboratories in March.

Near the end of the year experimental samples were received of Diazinon and Chlorobenzilate (Geigy Ltd.). Small-scale field tests were made with the former, using 20 per cent emulsion diluted to 0.1 per cent Diazinon against *Pericerya purchasi* on citrus. Results were very good as the heavy but small-scale infestation was eliminated in one spraying. Against *Aulacaspis cinnamomi* on mango a good but not complete kill was obtained. Chlorobenzilate was tried on a small scale in a field against the citrus bud mite *Aceria sheldoni* and after two sprayings at 0.1 per cent trees on which growth had been completely stopped by the mite started into rapid undamaged growth of many shoots, the controls not doing so. Microscopic examination after spraying did not reveal any living mites remaining but some buds still appear "stopped". The experiment was too small to be certain of the percentage kill resulting, but the material clearly shows great promise for the control of this mite.

In search for a substitute for Parathion, which is considered too dangerous to recommend in this country, where protective legislation does not exist, Malathion was tried in a number of small-scale field trials against a number of pests of citrus. The preliminary indications are that Malathion is effective against *Aonidiella aurantii, Pericerya purchasi* and *Trioza merwei*. Other insects present were Aphids (*Toxoptera citricidus*), *Ceroplastes* sp. and an Agromyzid leaf miner. Evidence was not sufficient to state if these were controlled. The trees were also infested with citrus bud mite, and as far as could be judged Malathion had no effect on the mite.

Under the stored products report is mentioned a test of insecticidal resins. A trial was also made of the urea formaldehyde resins containing 5 per cent Aldrin plus 10 per cent Dieldrin against cockroaches. The room was treated with the resin in May and thereafter until the end of the year no cockroach was seen in the room though no other treatment of any sort was applied. Previous to the resin application frequent treatments with insecticides were necessary if the numbers of cockroaches were not to rise rapidly.

Systematic Study of Coccidae

Mr. De Lotto has continued his work on the Coccidae and has also done general identification work for other officers of the section, and for other sections and departments. A start has been made on the detailed study and revision of the Ethiopian Mealy Bugs (*Pseudococcidae*) that is of the whole of Africa south of the Sahara. This important work has been planned and agreed as a joint project between the Commonwealth Institute of Entomology and this Department. This study will resolve a large number of uncertainties in the identification of insects of this important economic family, and put the work of biological control and other aspects of work on a sound basis. It will have important economic repercussions.

The general systematic study of the East Africa Coccids of the Departmental collection was continued and the identity of several species belonging to the important families of Pseudococcidae and Coccidae has been cleared up. From this study it has been found that some species of world wide distribution although not previously recorded do occur in these territories, whilst for a few others there is a strong likelihood that they do not occur here. Altogether about 30 or 40 species in the collection—including some of real economic importance –are apparently new and will be described in due course.

Cereal Pest Investigations

On Mr. Graham's return from leave near the end of October he was stationed at Njoro, to work on the life history and control of *Hylemyia arambourgi*, and of other cereal pests. He reports as follows:—

"The Barley Bulb Fly (*Hylemyia arambourgi*)

A generation of this fly was bred in barley during the short rains. After the rains a very limited stock has been maintained in irrigated barley. During the short rains eggs were found on the stems of barley. Those found since have been on the soil surface within the rows as well as on barley stems. The eggs are laid singly. They are white in colour and about 1.5 mm. in length. The diameter is about one quarter of the length and the outline in one plane is roughly sausage shaped and oval in plane at right angles to it. The chorion is finely reticulated. One egg kept indoors took over three days to hatch. In the field, where soil surface temperatures are usually higher, the period may be less. The newly hatched larva burrows in the soil alongside the barley seedling, entering the plant below ground level. Pupation may occur either in the remains of the plant or in the soil near it. Pupal periods of 15 days were ascertained indoors. In field conditions they may be less since the interval between the appearance of the barley above ground, and the emergence of adult flies can take less than 28 days.

Lepidopterous Stem Borers

Busseola fusca was reared from specimens obtained from barley. *Sesamia calamistis* was reared from Eleusine millet obtained from the Perkerra irrigation scheme."

Cotton Pest Investigations

Mr. Crowe was posted to Nyanza on 1st March, to work on cotton, sorghum and other pests. The major part of his time was devoted to cotton pests. He reports as follows:—

"The cotton season does not finish until March, 1955, so in this 1954 report it is only possible to give provisional conclusions.

Survey.—Routine observations were made on African-grown plots throughout the cotton-growing area. These observations included (1) counts of *Dysdercus* spp.; (2) estimation of *Lygus* damage by the "leaf grade" method developed in Uganda. Collection of shed bolls and buds (and "flared squares") and their subsequent classification according to the cause of shedding.

Three main divisions of the Province may be recognized which differ to some extent in the pest complex; but within each division the pest complex is broadly similar:—

(*a*) The Luo area near the shore of Lake Victoria. Here the *Dysdercus* populations were fairly large (up to about 6,000 adults per acre) but fluctuating. *D. superstitiosus* (44.6 per cent) and *D. nigrofasciatus* (53.2 per cent) were the dominant species. Occasional specimens of *D. fasciatus* and *D. cardinalis* were taken. *Lygus* populations built up to a peak about the beginning of September. A leaf grade of 1.79 (maximum = 4) was the highest recorded. *Lygus* was responsible for 23 per cent of shedding, bollworms (chiefly *Heliothis armigera*) for 14 per cent.

(*b*) Samia Location of Central Nyanza. Here the pest complex resembles that in Luo areas but populations are consistently smaller.

(*c*) North Nyanza near the Uganda border. *Dysdercus* populations were lower than in the Luo areas but *Lygus* populations were much larger. A leaf grade of 3.12 was recorded on one plot in mid-September. Numbers declined after this date and if the rains are favourable there is still hope of a reasonable picking in February and March, 1955.

When cotton picking was just about to begin extensive collections of large green bolls were made which were examined for bollworm and *Dysdercus* damage. Estimations of the average number of large bolls per plant —normal and mummified—were made by counting on randomly selected plants on over 200 plots throughout the Province. Certain of these counts are summarized in the following table:—

Area	% of large bolls mummified	% of Stained locules	% of large bolls with bollworn
Luo	14·2	42·2	1·2
N. Nyanza	9·1	29·9	3·1
Samia	5·2	16·1	1·0

It should be noted:—

(1) That the percentage of stained cotton will be lower than the percentage of stained locules since the peasant picks over lightly stained locules.

(2) Pink Bollworm (*Platyedra gossypiella*) was by far the commonest species in large bolls but occasional specimens of *Heliothis armigera*, *Earias* spp. and *Argyroploce leucotreta* were found.

EXPERIMENTAL

At three places on the Kano Plain large increases of yield (about 350 lb. A.R. cotton per acre increased to around 800 lb.) were achieved by high volume spraying of 1 lb. D.D.T. per acre plus 0.3 lb. gamma isomer B.H.C. per acre five times at 10-day intervals during August and September. Later spraying periods (September–October and October–November) were less successful. This was apparently because the plants were beginning to senesce

owing to the gap between the long and short rains. At one place an identical experiment failed completely. It is believed that this was due to a peculiar rainfall distribution.

At Kibos Cotton Experiment Station a trial was done to compare the high volume treatment mentioned above with a low volume treatment of the same dosage and the two standard cotton dusts (3 per cent gamma B.H.C. with 10 per cent D.D.T. and 3 per cent gamma B.H.C. with 5 per cent D.D.T.) applied at 20 lb. per acre. The 3 : 10 cotton dust was slightly but significantly superior to the other three treatments which were not significantly different. Since the Nyanza cotton areas are very poorly watered most experimental work will be done with dusts in subsequent seasons.

A *Lygus* control experiment was also done using McKinley's design, where the plots are single rows in a matrix of unsprayed cotton. Treatments were weekly sprayings with 0.1 per cent D.D.T. in August-September, October-November, August-November and no spraying. The experiment was disappointing in so far as only partial *Lygus* control was achieved during the spray period. Only early spraying gave a significant increase in yield over the control plots but on all the sprayed plots there was some evidence of partial *Dysdercus* control in that the percentage of clean cotton rose from 50.3 per cent on unsprayed cotton to 60.6 per cent on the plots continuously sprayed. However, a large number of large bolls on all plots were completely mummified, largely due to stainer attack.

An experiment where single, double and triple rows of cotton were interplanted in maize, sorghum and groundnuts gave no evidence that any degree of control of cotton pests could be achieved by this means. Bait sprays for stainer using B.H.C. or Malathion were fairly successful in laboratory tests and will be tried out in the field next season.

It is of interest to note that populations of *Lygus* and *Dysdercus* spp. were higher on the experimental farms than in the Reserve. *D. fasciatus*, which is uncommon on African plots, is one of the commonest species at Kibos.

Sugar Cane.—A large increase in the acreage of this crop is envisaged under the Swynnerton Plan. In certain areas in North and South Nyanza it is difficult to establish owing to termite attack in the first weeks after planting. An experiment was laid down on some heavily-infested land at Homa Bay Experiment Station.

The insecticide used was B.H.C. ("Agrocide 7").

(*a*) Initial dose only, equivalent to 70 lb./acre of Agrocide 7.

(*b*) Same weight in three doses. Initial 40 lb., two months later 20 lb., two months later, 10 lb.

(*c*) Control.

The initial doses were dusted into the planting furrow just before planting. Germination was best in the (*b*) plots. 70 lb./acre in one dose appeared to be somewhat phytotoxic. Observations suggested that a single dusting of 40 lb. at planting would have given sufficient protection. Further tests with B.H.C. and Dieldrin will take place next season.

Miscellaneous

A survey was made of the distribution of the banana weevil, *Cosmopolites sordidus*, and the sorghum midge, *Contarinia sorghicola*. in Nyanza. Up to the end of the year the former, though present in North and Central Nyanza, had not been found in South Nyanza. The latter was universally found in

sorghum-growing areas but was nowhere seen causing great damage. A small but increasing volume of advisory work was also done, most specimens coming from Field Officers.

The following records are of interest:—

COCCIDAE—

Aonidimytilus albus.—Noted on several plots of cassava but since it is chiefly on old plants, its status as a pest seems doubtful.

HISPIDAE—

Damage to rice was caused by Hispid beetle in Central Nyanza. Some plots were dusted with 1 per cent D.D.T. but the results were inconclusive.

DYNASTIDAE—

Heteronychus spp.—Two species attacked young sugar cane on flooded plots in South Nyanza.

LYMANTRIIDAE—

Porthesia producta.—Caterpillars defoliated Castor in Central and South Nyanza but they were heavily parasitized by an unidentified Braconid and the attack soon subsided.

GALERUCIDAE—

Ootheca benningseni.—This beetle did considerable damage to beans in South Nyanza.

COCCINELIDDAE—

Hyperaspis jocosa.—This insect was liberated at Kisumu to control *Orthezia insignis* in 1951 and is now well established. Colonies of *Orthezia* are very small and adults and larvae of the beetle almost invariably present."

General Investigations

BIOLOGICAL CONTROL OF *Orthezia insignis*

A small breeding stock of *Hyperaspis jocosa* was maintained throughout the year and a few liberations made. There was little or no demand for this predator in contrast to the previous heavy demand, which indicates the great measure of control achieved. A small breeding stock of the species *Hyperaspis donzeli* was kept going but efforts to produce this in sufficient numbers for liberation have not yet been successful.

BIOLOGICAL CONTROL OF *Lantana*

The rearing of the Tingid bug *Teleonemia scrupulosa* continued through the year and liberations were made at Matuga, Donya Sabuk and Kiambu on *Lantana camara.* A total of over 4,000 insects were released. Establishment has not been confirmed, but the rearing continues and further liberations will be made.

CITRUS BUG MITE *Aceria sheldoni* (EWING)

This Eriophyid mite was recorded for the first time in Kenya during the year, being found at Lower Kabete. It is widely spread in Kenya and a very serious pest of citrus, causing leaf, shoot and fruit distortion; sometimes this is so severe

as to inhibit the growth of the tree almost completely. It may well prove to be an important cause of the poor growth made by much of the citrus in this country. Here it is most serious on lemons but also very severe on grapefruit and fairly severe on oranges. It is believed that it has been imported on citrus trees from South Africa in the last few years, though its presence there has only recently been recorded, but it is also probable that it has been present in Kenya undetected for many years. Damage identical with that caused by the mite was recorded and illustrated in the 17th century, but the mite was first recognized in California in 1937. It has now been found in many parts of the world and is much more widely spread than was previously thought. Lime sulphur and petroleum oils have been the standard method of control up to the present but the new miticide chlorobenzilate appears from preliminary tests to be very effective. Further trials are planned.

Coreid Bug of Coconut

The work on this very severe and important pest was in abeyance during the year owing to the full-time call-up of the Entomologist for Emergency police duties. This country was therefore unable to fulfil its agreed part in the co-ordinated plan of research with other territories.

Field Infestation of Bruchids

A second insecticidal field trial was carried out at Embu against Bruchids on beans in 1954, planting taking place in April, the field work being carried out by the Agricultural Officer, to whom thanks are given. Four half-acre plots were given two treatments of 5 per cent D.D.T. dust, the first in June and the second in July. Four more half-acre plots were left untreated as controls. The beans were harvested in August. During the experimental period the rainfall was unusually heavy. From the counts made of samples from each plot, the percentage of Bruchid infested beans was found to be 0.1 per cent in the treated plots, and 0.3 per cent in the untreated, the difference probably not being significant. These are lower than the figures for 1953, although the 1954 season was much wetter. It appears therefore that the field infestation is very low, insecticidal treatment would not be economic, and control of the Bruchid must be achieved after harvest in the various stages of storage.

Miscellaneous Pests

The following pests were recorded as doing damage during the year:—

Argyroploce leucotreta	Peaches	Kitale
Chrysomphalus pinnulifer	Ficus sp.	Kabete
Pachnoda sinuata	Mangoes	Nairobi
Melanagromyza phaseoli	Beans	Naro Moru
Achaea catocaloides	Wattle, maize	Kisumu, Kitale
Callidea bohemani	Beans	Sotik
Apate monacha	Avocado Pear	Sotik
Antonina graminis	Grass	Kisumu, Nairobi
Laphygma exempta	Maize	Kitale, Nairobi
Dacus vertebratus	Cucurbits	Nairobi
Athalia sp.	Vegetables	Athi River
Plataspis galerucoides	Ficus sp.	Konza
Nematocerus sp.	Wheat, maize	Solai, Njoro
Toxoptera citricidus	Citrus	Kabete
Dasus simplex	Wheat, maize	Eldoret, Solai
Phynocolus sp.	Wheat, maize	Solai
Atherigona indica infuscata	Brachiaria brizantha	Kitale
Heteronychus sp.	Maize	Eldoret

Aonidiella aurantii	Citrus	Kitale
Pericerya purchasi	Citrus	Kitale
Adoretus fuscovittatus	Wheat	Njoro
Camenta sp.	Wheat	Njoro
Megalognatha metallica	Wattle	Kericho
Heteronychus consimilis	Wheat	Sotik
Busseola fusca	Maize, sorghum	Nakuru
Dysmicoccus brevipes	Pineapples	Thika
Hylemyia arambourgi	Barley	Solai. Njoro
Ceratitis capitata	Citrus	Kiambu
Colias electa	Lucerne	Ol Joro Orok
Estigmene multivittata	Grass	Eldoret
Epilachna similis	Wheat	Elmenteita
Aulacaspis cinnamomi	Mangoes	Nairobi
Icerya seychellarum	Roses	Mombasa
Africaspis chionaspiformis	Erythrina caffra	Kitale
Epimadyza nigra	Gladiolus	Limuru
Lyctus brunneus	Timber	Nairobi
Ferrisiana virgata	Narcissus	Mombasa
Aceria sheldoni	Citrus	Kabete
Plutella maculipennis	Brassicas	Naro Moru
Lepidosaphes beckii	Citrus	Namanga
Chrysomphalus rossi	Citrus	Namanga
Hyperacantha usambarica	Coffee	Teita
Adoretus pagenstecheri	Bombax sp.	Kabete
Deudoryx antalus	Chilli pods	Kwale
Haltica pyritosa	Horse radish	Kitale
Heliothis armigera	Tomato fruit	Nairobi
Apion sp.	Plumeria sp.	Kabete
Argomyza coffeae	Coffee leaves	Kabete
Cryptoflata unipunctata	Citrus	Kabete
Systates crenatipennis	Citrus	Kabete
Hilda sp.	Citrus	Kabete
Diplognatha silacea	Hagenia anthelmintica	Kabete
Thorictodes heydeni	Gram	Mombasa
Locris ochroptera	Grass	Njoro
Tribolium castaneum	Walnuts	Nairobi
Alphitobius piceus	Stored maize	Nairobi
Sitotroga cerealella	Stored maize	Nairobi
Plodia interpunctella	Stored maize	Nairobi
Tetranychus sp.	Citrus	Kabete
Ephestia cautella	Stored maize	Kitale
Corcyra cephalonica	Stored maize	Kitale
Acanthoscelides obtectus	Beans	Nyanza
Calandra oryzae	Stored maize	Nyanza, etc.
Callosobruchus maculatus	Green gram	Nyanza
Callosobruchus chinensis	Cowpeas	Taveta
Laemophloeus minutus	Sorghum	Nyanza
Oryzaephilus surinamensis	Maize	Nyanza
Rhizopertha dominica	Sorghum	Nyanza
Stegobium paniceum	Beans	Nyanza
Tenebroides mauritanicus	Maize	Nyanza
Tribolium confusum	Stored rice	Nyanza
Necrobia rufipes	Copra	Mombasa
Sesamia sp.	Sorghum	Nairobi
Atherigona sp.	Sorghum	Shimba
Ootheca benningseni	Beans	South Nyanza
Lasioderma serricorne	Dried lettuce	Kisumu
Ceroplastes destructor	Citrus	Kisii

INSECT COLLECTION AND COMPILATION OF RECORDS

Work on the collections has continued with some interruptions due to pressure of other work and shortage of staff. Many new records have resulted from this work with the help of the identification services of the Commonwealth Institute of Entomology, London. The card index has been increased by the inclusion of insects in some of the East African collections, and by compilation from a number of past volumes of the Zoological Record. It is hoped that good progress on the Pest Life will be possible during the year.

Insects Identified in 1954, *being New Records*

CURCULIONIDAE—		
Blosyrus regulosus	Ipomoea batatas ..	Nyeri
Babaultia ebenina	Sorghum, maize ..	Makueni
Peritelomus bicruciatus ..	Dombeya sp. ..	Kibarani
Systates lepidotus	Cotton	Kibarani
Omophorus stomachosus ..	Tecoma sp.	Kabete
Alcidodes haemopterus ..	—	Kabete
Lecanophora setulosa ..	Maize, flax	Solai, Rongai
Ocladius longipilosus ..	Grass	Solai
Menemachus nigrocaudatus ..	Grass..	Solai
Ochnodes lepelleyi	Grass..	Solai
Epactus coenosus	Grain store	Kinangop
Phoromitus undaticollis ..	Wattle	Kikuyu
TENEBRIONIDAE—		
Alphitobius piceus	Maize	Nairobi
Tribolium anaphe	ex dried locusts ..	Nairobi
THORICTIDAE—		
Thorictodes heydeni	Gram	Mombasa.
BRUCHIDAE—		
Bruchus erythraeus	Maize	Nairobi
TINGIDAE—		
Compseuta montandoni ..	Sida cordifolia ..	Kilifi
Phyllontocheila subinermis ..	Glycine javanica ..	Nairobi
Monanthia comes	—	Kiambu
Cochlochila kilimensis ..	Ocimum sp. ..	Nairobi
MEMBRACIDAE—		
Xiphopoeus erectus	Bidens pilosa ..	Nairobi
TACHINIDAE—		
Voria capensis	*Plusia orichalcae* ..	Molo
Linnaemyia alopecina ..	Plusia orichalcae ..	Molo
Nemoraea rubellana ..	Laphygma exempta	Nairobi
Sturmia (Prosturmia) zonata	Laphygma exempta	Nairobi
MUSCIDAE—		
Atherigona indica infuscata ..	Brachiaria brizantha	Kitale
AGROMYZIDAE—		
Phytomyza atricornis ..	Petunia leaves ..	Kabete
ACARINA—		
Aceria sheldoni	Citrus	Kabete

Publications

R. Le Pelley and S. Kockum—

"Experiments on the use of Insecticides for the Protection of Grain in Storage". *Bull. Ent. Res.*, Vol. 45, Pt. 2, June, 1954, pp. 295–311.

G. De Lotto—

"Three Apparently New Mealy Bugs from Kenya". *Proc. R. Ent. Soc. Lond.* 23: 110–114, illus.

"Three New Coccids Attacking Coffee in East Africa" (in press).

"New Diaspidini from Kenya" (in press).

"Three New Coccoidea from Eritrea" (in press).

"The Identification of some East African Species of Saissetia" (in preparation).

"Miscellaneous Coccid records from Africa" (in preparation).

Acknowledgments

I wish to acknowledge the good work of all the European and African members of the section. A high standard of work was maintained despite a good deal of sickness and shortage of staff. Assistance from the Field Staff of the Department was received for which we are grateful. Once again the great help afforded by the Commonwealth Institute of Entomology is acknowledged with pleasure—this help is indeed essential to the work of the section.

R. LE PELLEY.
Senior Entomologist.

ANNUAL REPORT OF THE SENIOR RESEARCH OFFICER, PLANT PATHOLOGY, 1954

With the transference of cereal pathology and advisory work from the main pathology to the Plant Breeding Section, there has been a falling off in the number of inquiries. Three hundred and thirty-seven specimens of diseased material were received from official and private sources as against 405 in the previous year. After the initial survey of the incidence of the maize rust, *Puccinia polysora,* further study of the fungus and the considerable programme of maize breeding and testing for resistance and the identification of physiologic forms became the concern of a joint undertaking by the East African Agriculture and Forestry Research Organization and the Kenya Plant Breeding Section.

No new diseases of economic importance have been recorded during the year. Some concern was felt over the reported outbreak of the Argentine Sunflower virus disease in Uganda. Agricultural Officers were warned of the possibility of the disease reaching Kenya and were asked to report any suspicious symptoms. A report from the Nyanza Province was investigated and a survey made of sunflower crops in that Province and at Kitale. Although in three localities virus-like symptoms were present sporadically in the crops including a marked mottling of the involucral bracts no described stem lesions and twisted petioles were seen and no reaction followed attempts to inoculate *Petunia* leaves. Seed from heads showing marked symptoms produced normal plants. Although a mild virus may be the cause of the observed symptoms, it seems that in view of the wide host range and number of vectors of the Argentine disease that it has not reached Kenya.

An apparently new disease of strawberries has, during the year, become serious in two localities. The roots die and shrivel from the tips and a leaf necrosis develops from the tips and margins spreading backwards across the lamina and down the petiole. No pathogen was obtained from the diseased leaves but the roots yielded a range of weakly parasitic soil fungi but with no recognized pathogen such as *Verticillium.* The disease seems to be similar to that described in other countries as "Black Root Rot" and is attributed to a number of conditions which promote an attack on the roots by fungi not normally parasitic. It was thought that the conditions leading to this state were in the one a mineral deficiency and in the other over-irrigation with impeded drainage.

Ratoon Stunting of sugar cane has been identified by Dr. Storey in the Nyanza Province but he was unable to demonstrate the presence of "Chlorotic Streak" from suspected material from the same source. The virus disease of sweet potato, previously reported, is being intensively studied by E.A.A.F.R.O., it being considered a disease of considerable economic importance. There is still no evidence of the presence of Tomato Spotted Wilt virus in the Colony to the exclusion of which strict quarantine of perennial host plants is directed. Limited importation of ornamental plants, which cannot be certified as inspected during growth are grown and tested at the quarantine station maintained by E.A.A.F.R.O. under the direction of Dr. Storey. The establishment of this station on behalf of the three territories has relieved the section of a considerable burden and responsibility and enabled importations to be made which in the past were prohibited. In connexion with the importation of chrysanthemums, Aspermy disease of tomatoes is tested for as well as Spotted Wilt. At the Coast Horticultural Station "Stem Pitting" of grapefruit is reported to be present in nursery stock.

A new disease of pyrethrum was reported by the Agricultural Officer (Pyrethrum) from the Molo and Subukia districts. The disease is not unlike that caused by *Ramularia* and attacks the buds and flowers causing a similar overall effect. From preliminary investigation it seems that the pathogen is a species of *Ascochyta*. From inoculations with cultures of the fungus it appeared that the progress of the fungus was more rapid than *Ramularia* and in addition to permeating the bud or flower head extended a greater distance down the flower stalk. Large, widely spaced pycnidia occur on the bracts and base of the involucre. The two diseases can be distinguished by the angle to the stalk made by a killed head. In *Ramularia* the head is bent sharply to one side whereas in *Ascochyta* the neck of the stalk is bent over in a rounded curve. Although when first observed there seemed cause for alarm, the disease remained localized and with the setting in of dry weather subsided. At the height of its severity, however, when both diseases were present in the same crop, the number of heads attacked by *Ascochyta* outnumbered those of *Ramularia*. The controlled-climate cabinet has now been completed and is in operation in the study of *Ramularia* disease and in the testing of clones for disease resistance. Through the courtesy of the Royal Botanic Gardens, Kew, seed of a number of chrysanthemum species has been obtained and plants raised. Attempts to inoculate these with *Ramularia* have, so far, failed. The embedding and sectioning of a series of buds to follow the process of infection and invasion of the tissues is now in progress.

A bacterial disease of the Globe Artichoke, not previously recorded in Kenya, occurred on a five-acre plot of this crop on the shore of Lake Naivasha. Only the flower buds and heads are involved, the main parts being the involucral bracts. Since every bract in the involucre is similarly affected in any one head, it is assumed that infection occurs in the bud stage when the tips of all the bracts are in contact. Buds infected at a still earlier stage are killed and blackened to the base of the receptacle. The disease is not crippling nor has it any permanent effect on the plants. With each bract of the involucre infected from the tip and involving half or more of the organ the appearance in the field is striking. In this outbreak, since virtually all the bracts were affected the crop was commercially a total loss. No other planting in the vicinity was similarly attacked. The pathogen, which is being studied, is probably a species of *Xanthomonas*.

Antirrhinum Rust, *Puccinia antirrhini*, appeared in Kenya. An outbreak occurred in a public park in Nairobi, in a nursery a few miles distant and on the shore of Lake Naivasha. Scab, *Elsinoe* (*phaseoli*), newly recorded on this host in Kenya, caused damage to crops of *Dolichos lab-lab* south of Nairobi. On pulse crops this genus has, hitherto, been observed on *Phaseolus aureus* only. Canadian Wonder beans in a number of localities were attacked by *Ascochyta phaseoli* causing, in some instances, severe pod damage.

Crown Gall continues to cause damage to fruit trees notably apple, plum and peach, in a number of localities. Contrary to views expressed in other countries the galls have a serious effect on the host trees and in the opinion of the Horticultural Officer can cause serious debilitation or premature death. An instance of suspected Hairy Root occurred at Molo.

Among other diseases received at the laboratory were *Sclerotinia sclerotiorum* on asparagus, *Gerbera*, sunflower and veronica; a *Phomopsis* basal canker on geraniums grown for essential oil; a similar disease on cassava and a *Phomopsis* pod rot of chillie; *Cercospora beticola* leaf spot of spinach beet; *Xanthomonas campestris* on cabbage; *Uncinula necator* on vines causing severe cracking of the

fruit; *Oidium* on pawpaw; *Helminthosporium cynodontis* on golf greens; *Roselinia necatrix* on pear; a severe attack of *Puccinia chrysanthemi* on chrysanthemums; *Botrytis cinerea* on gladiolus flowers and a soft rot of the corms caused by *Fusarium oxysporum* in a commercial plantation; and a root and crown rot of pyrethrum caused by *Rhizoctonia solani*. *Colletotrichum capsici* caused considerable damage to pods of *Capsicum annuum* approaching maturity in the Coast Province.

Serious loss to the chillie export crop at the Coast was attributed to insufficient or too slow drying, or storage after drying in circumstances which allow absorption of moisture during particularly humid periods. Pods were, in some instances, blackened presumably by fermentation setting in, only rarely was a species of *Penicillium* present. Information was sought by the Industrial Research Board on a blackening of tallow and pomade used in the extraction of flower perfume. The discoloration was found to be due to growths of *Cladosporium herbarum* and a species of *Penicillium* growing from fragments of flower debris. The development of the fungi apparently resulted from inadequate or faulty application of the disinfectant. The *Cladosporium* occurred in the samples of tallow, but not in the pomade in which the discoloration was caused by *Penicilium* alone but of a different species from that in the tallow. *Aspergillus tamarii* was found contaminating maize meal in a stored products experiment.

The preparation and distribution of cultures of legume nodule bacteria continued to occupy much of the time of the section. The standard charge of Sh. 1 for each unit sufficient to inoculate 20 lb. of small seed was maintained. A total of 231 cultures was issued during the year for the following quantities of seed totalling over 45,000 lb.: lucerne 14,060 lb. lupin 13,320 lb., pea 10,160 lb., cowpea group 1,720 lb., soya bean 1,400 lb., clovers 1,100 lb., beans 1,080 lb., sunnhemp 1,060 lb., serradella 1,040 lb., subterranean clover 400 lb., *Glycine* spp. 200 lb., others 800 lb.

Routine tests and periodic re-isolation of stock strains, after passing through the host plant to maintain nodulation and nitrogen fixation efficiency, were continued. The move into the new laboratories in October made available a separate culture room for legume bacteria which has facilitated the maintenance and despatch of cultures. Adaptations have been made to the standard testing technique. The strains are tested under identical controlled conditions. The surface sterilized seeds are placed in sterilized plugged boiling tubes containing a standard rooting medium of 50 per cent graded vermiculite and 50 per cent graded sand of pH. 6.9 and moistened with the standard nitrogen-free nutrient solution. Inoculation is made at the time the seeds are placed in the tube. The tubes are kept in the laboratory and illuminated with fluorescent light of fixed intensity (weston 200) during the hours of daylight.

In view of the importance of legumes in pasture research work, special attention has been paid to the provision of efficient bacterial culture for indigenous and exotic pasture plants which are of importance in temporary leys and which are the subject of experimentation by the Pasture Research Team. Some of these legumes have already been shown to be strain specific and others have reacted indifferently with the omnibus group cultures. Work is now in progress with a view to providing for each pasture legume its own strain of bacteria. A new strain has, for instance, been obtained for *Trifolium alexandrinum* (Berseem clover), all previous strains having proved unsuitable. Isolations are made from time to time from exceptional plants collected by the Pasture Research Team. In addition to the indigenous bacteria, commercial cultures from countries in Europe and Australia have been re-isolated from inoculated plants. A trial is in progress to compare the efficiency of similar group cultures from different

sources and with the local specific isolations. This is being done concurrently in the field at the Pasture Research Station, Kitale. In the laboratory Group 5 (Cowpea) produced by a commercial firm in England and a Scott Laboratory isolation were tested on species of *Alysicarpus, Antopetitia, Astragalus, Centrosema, Crotalaria, Dolichos, Eriosema, Glycine, Indigofera, Phaseolus, Rhynchosia, Stylosanthes, Tephrosia, Teramnus* and *Vigna*. In some of these trials neither culture produced nodules and in others the local isolation proved superior.

An important problem in connexion with pasture research is that in certain districts, particularly Kitale, some indigenous and exotic legumes either nodulate unsatisfactory or not at all and in field plot trials fail to nodulate when inoculated with cultures shown to be effective in the laboratory. A series of experiments is now in progress in the laboratory to find out what are the inhibiting factors. In these experiments inoculated and uninoculated seed is sown in sterilized and natural soil from Kitale with adjusted pH and phosphate content. Controls are in vermiculite with nutrient solution. The possible factors limiting or inhibiting nodulation, and which the experiments are designed to indicate, are physical character and reaction of the soil, lack of phosphate and biological antagonism of which a bacteriophage is considered a possibility. It was suggested that a possible cause of the failure of cultures sent from the laboratory to Kitale was deterioration in transit while in charge of the post office and railway. An experiment extending over a period of wet and dry seasons whereby cultures were returned to Nairobi from Kitale showed that no deterioration of the strain tested (lucerne) occurred.

Trials of blight-resistant potatoes have been continued during the year. A few tubers of four differentials for the identification of races of *P. infestans* were kindly supplied by Dr. Black. Blight was again prevalent and certain of the varieties under trial remained free. In all, 21 varieties were grown in plots at Embu, Nairobi and on the E.A.A.F.R.O. farm at Muguga. A few of the most promising varieties were issued to farmers for trial. The races of *P. infestans* so far identified in Kenya are A., C., D., G. and H.

Tomatoes were in all districts severely attacked by blight. A few seeds of a tomato having resistance to the common tomato race of *P. infestans* and "some minor gene resistance giving partial protection against all races so far employed" were kindly supplied by Dr. Black. Plants were raised at the Scott Laboratory in the field. All plants were attacked by the first wave of blight and subsequently suffered from fruit infection through the dry season before the short rains. The blight has been transferred to potato tuber and sent to Dr. Black for identification of the race concerned.

During the year 49 specimens of fungi were sent to the Commonwealth Mycological Institute. The following determinations were received:—

Actinomucor repens on *Begonia*; *Ramularia decipiens* on *Rumex*; *Erysiphe polygoni* on *Pisum sativum*; *Uncinula aspera* on *Ficus hochstetteri*; *Botryodiplodia theobromae* on *Aleurities* and *Cocos nucifera*; *Cerebella andropogonis* on *Pennisetum mezianum*; *Nigrospora sphaerica* on *Zea mays*; *Cercospora solani-melongenae* on *Solanum incanum*; *Cercospora henningsii* on *Manihot utilissima*; *Botrytis cinerea* on *Gladiolus*; *Ascochyta rhei* on *Rheum rhaponticum*; *A. pisi* on *Pisum sativum; A. sojaecola* on *Glycine javanica*; *A. cynarae* on *Cynaria scolymus*; *A. gerberae* on *Gerbera jamesonii*; *Colletotrichum lindemuthianum* on *Phaseolus vulgaris*; *C. agaves* on *Agave sisalana; C. capsici* on *Capsicum annuum*. Unidentified species were *Phomopsis* on *Manihot utilissima*; *Botryodiplodia* on *Ricinus communis*; *Phyllosticta* on *Solanum incanum*; *Ascochyta* on *Penstemon*; and *Colletotrichum* on *Solanum*.

Seed-Testing Laboratory

The work of the seed-testing service has been greatly facilitated by the move, towards the end of the year, into the new laboratory. The present accommodation provides an adequate seed-testing room with a separate sterilizing and wash-up room and a balance room. The number of samples sent in for testing was 907, consisting of cereals 458, legumes 95, grasses 281, vegetables 26, flowers 23 and other crops 24.

A problem arose during the year over the germination of Herta and Abed Kenia barleys, both of which came to maturity later than other barleys. It was claimed that the comparatively low figures obtained in the laboratory on the standard sterilized sand medium was not reflected in the field even when sown without any considerable period of storage. When the sterilized sand was replaced by unsterilized soil, the germination figure was much improved and approximated that of other mature barleys. When fully mature, after a period of storage, the germination percentage for sterilized sand and unsterilized soil were much the same. It was suggested, however, by the cereal specialists that soil should replace sand as the standard medium in order more accurately to assess the planting value of the samples. An experiment, designed and interpreted by the Statistician of E.A.A.F.R.O., with mature barley of the varieties Abed Kenia, Herta, Research and Prior with sterilized sand and unsterilized soil showed a slight advantage in favour of sand. With these two barleys, in a state of immaturity, sterilized soil gave a similar low figure to that of sterilized sand. It seems that a factor which, to some extent, counteracts the effect of delayed maturation, exists in soil and is removed by the process of sterilization. Further trials on these media with the above four barley varieties at different stages of maturity are planned.

A series of germination tests on wheat and barley treated with Dieldrin and Aldrin, at standard, and double the standard rates, was done for the Entomological Section. In these tests neither insecticide had any depressing effect on germination. Certificates of germination were given for all samples of maize entered for the annual maize competition, and for all cereals entered for the Royal Agricultural Show of Kenya. Previously certificates were required only for grasses. A number of samples of Rhodes Grass were tested for the Pasture Research Station in connexion with an experiment on fertilizer application and row spacing. Samples were sent in from the same station for purity and germination tests on seed put through an experimental seed scarifying machine. Tests done on local clover seeds for the Pasture Research Officer, Molo, showed that scarifying with carborundum powder and mortar and pestle was better than steeping in sulphuric acid or plunging into boiling water. Processing of grass seed with a small hammer mill, using different screens, was done by the Pasture Research Station and samples sent to the laboratory for examination and testing. With *Panicum maximum* winnowing and cleaning gave the best results, with *Cenchus ciliaris* and *Brachiaria brizantha* milling only and with *Chloris gayana* and *Melinis minutiflora* no treatment were superior to other treatments. The milling of *Chloris gayana* revealed among the naked caryopses a number of ergot sclerotia which are only slightly longer than the caryopses and of a putty-like texture. Samples of cotton seed drawn from different depths of bulk-stored seed were sent in for testing. No significant difference in germination was found in samples from 0 to 12 inches, 12 to 24 inches and 24 to 36 inches. Several tests were done on *Salvia* seed for a farmer who wished to know the optimum stage of ripeness for harvesting. It was found that only when the seed was harvested fully ripe was there full germination. Seed harvested before this stage needed some months of after ripening but even then does not reach the standard of the fully ripe seed. As the crop was grown on contract

for a firm in the United Kingdom and paid for on a germination figure the question was one of importance for the grower. Treatment by oven drying for three days at 40° C. increased the germination of immature sunflower seed from 30 per cent to 95 per cent.

During the year 74 specimens were added to the herbarium and 71 specimens of plants were received from public and official sources for identification. *Physalis minima* was received several times and appears to be increasing rapidly in the Solai Valley. From many districts was sent a species of *Coleus* not previously ranking as a weed of importance. The collection of named varieties of beans maintained for the purpose of identification of specimens was increased by a valuable contribution of named varieties from the Belgian Congo. A collection of Kenya beans cultivated in the Embu district was received from the Agricultural Officer (Experiments) and sent to the Congo in return.

Visitors from outside Kenya who visited to see the working and methods of the laboratory were Messrs. N. Joy (Tanganyika), C. R. Horrell (Uganda) and A. E. Riley (Northern Rhodesia).

The following fungi occurred on various samples:—

Wheat—"Black Point", grains associated with *Alternaria tenuis, Cladosporium herbarum, Epicoccum* sp., and the teleuto stage of *Puccinia graminis.* Oats—*Epicoccum* sp. and *Sphacelia* sp. Maize—*Fusarium gramineum* and *Sphacelotheca reiliana.* Lupin—*Alternaria tenuis, Fusarium* sp., *Tricothecium roseum, Verticillium cinnabarinum.* Cotton—*Aspergillus melleus, A. niger, Chaetomium cochlioides, Rhizopus stolonifer* and *Tricothecium roseum.* Ergots occurred in *Cenchrus ciliaris, Chloris gayana, Panicum maximum, Paspalum dilitatum, Brachiaria brizantha. Puccinia graminis* and *Helminthosporium* sp. occurred on the grains of *Brachiaria brizantha* and *Tilletia echinosperma* on *Setaria splendida* and *S. sphacelata.*

Tests of samples of imported peas for presence of *Pseudomonas pisi* all proved negative.

R. M. NATTRASS,
Senior Research Officer (Plant Pathology).

ANNUAL REPORT OF THE SOIL CHEMIST, 1954

Fertilizers and Fertilizer Studies

A small supply of single superphosphate was put on the market at a number of the more important trading centres in North Nyanza. Kimilili and the southern part of the district received particular attention, responses to phosphate in trials there having been particularly consistent and satisfactory. Unfortunately, however, the supply arrived too late to be of much use to the long rains planting and very little was taken up. African farmers in the area were introduced to fertilizer usage by demonstrations which were put down at 68 centres, chiefly on African holdings, concentrated in the responding areas. At each centre a $\frac{1}{4}$-acre plot without fertilizers was compared with a similarly sized plot on which 2 cwt. per acre of single superphosphate had been applied. At six of the Kimilili centres a third plot was included in each demonstration on which the superphosphate application was followed by a mid-season top dressing of 2 cwt. per acre of sulphate of ammonia: these six trials were in an area in which nitrogen as well as phosphate responses had been recorded. Usually maize but occasionally sorghum was the demonstration crop. Except where nutrient deficiency was great, these demonstrations showed that the benefits to be obtained from fertilizer usage depended greatly on the standard of husbandry maintained by the cultivator. Timely planting and clean weeding during early growth were quite as important as fertilizer application for getting the crop away and were essential for achieving the maximum benefit from fertilizer application. In particular, on one holding where Striga infestation was severe, the infestation was made so much more severe by the phosphate application that the effect of fertilizing the maize there was devastating. At 38 centres the demonstrations were carried through successfully to harvest. Of these, 12 were near Kimilili and 17 were in the Southern area. The following table details the mean yields obtained from those demonstrations which were successfully harvested.

Zone	Yield: Lb./Dry Grain per Acre		
	No Fertilizer Plots	Phosphate Plots	Phosphate and Nitrogen Plots
Kimilili (mean of 6)	1,698	2,444	3,382
Kimilili (mean of 6)	3,076	3,582	—
Southern Area (mean of 17)	2,078	2,684	—
General average (mean of 29)	2,206	2.820	—

The demonstrations thus confirm that in the responding areas, important increases in crop (amounting in the demonstrations on average to 27.8 per cent) were obtained from the phosphate application and that where nitrogen also had been found beneficial in field trials, a further increase (amounting on average to 38.4 per cent) was obtained from its application. On the basis of maize at 15 cents per lb., of superphosphate at Sh. 1 per lb., P_2O_5 and of sulphate of ammonia at Sh. 1/50 per lb., these mean gains represent net profits per acre in responding areas of Sh. 51/80 from the superphosphate application and Sh. 70/70 from the nitrogen application. Where the "no phosphate" yields were over 15 bags per acre, phosphate application proved much less reliably beneficial than where the "no phosphate" yields were lower. This relationship is statistically significant (P less than .05) over the 38 sites and is expressed by the regression equation

$y = 1052 - 0.221x$ where y is the response and x is the no phosphate yield, both in lb./acre. Nitrogen application in responding areas was economic even where heavy crops were obtained without nitrogen.

Nine other demonstrations and 13 2^3 factorial N, P, manure trials elsewhere in North Nyanza and four similar exploratory trials in the Kisii Highlands, hold promise of there being further areas in which phosphate and nitrogen application would be of value. Four exploratory trials on Kericho red loam gave results which hold very great promise for the economic use of phosphate on cereals on that soil. The mean yields obtained in these exploratory trials were as shown in the following table:—

Zone	Yield: lb./dry grain per acre					
	Manure		Phosphate		Nitrogen	
	with	without	with	without	with	without
North Nyanza—						
West division	2140	1620	2120	1640	1960	1800
East division	2660	2440	2640	2460	2700	2420
Wanga division ..	3500	3000	3440	3040	3440	3060
Kisii Highlands ..	3920	3600	3900	3620	3800	3740
Kericho—						
Belgut division ..	2360	1940	2420	1880	2180	2120

Similar exploratory trials were undertaken at two centres in Rift Valley African areas and at four centres in the bracken belt of Central Province, results from which are awaited. Six 2^3 exploratory fertilizer trials involving N, P and K were laid down in the Coast Province, on soils derived from Magarini sands. The few of these trials which were carried through to a successful harvest lend support to the evidence which had previously been obtained of the phosphate deficient status of such soils.

The exploratory fertilizer trial programme continued to be supported by longer term, more complex and more critical fertilizer trials sited mainly on experimental stations and major settlement projects. The following table summarizes the results obtained from those trials for which three years accumulated results are available:—

Centre Altitude and Soil	Season and Rainfall during growth Yield units	Crop Fertilizer Treatment	Level	Yield Data: Fertilizer		
				N	P	K
Matuga 400 ft. Freely drained acid sand of low fertility derived from Magarini sands.	L.R. 1952. 10·33 in. lb. grain/acre	Dwarf ..	0	1151	853	1228
		Hegari ..	1	1164	1258*	1172
		Sorghum ..	2	1329	1528**	1244
		N, P and K applied				
	S.R. 1952. 8·85 in. cwt. dry haulms/acre	Cow peas ..	0	59·8	47·8	59·6
		Residual ..	1	59·7	65·2**	62·8
			2	63·0	69·5**	60·1
	L.R. 1953. 20·34 in. lb. grain/acre	Dwarf ..	0	180	276	224
		Hegari ..	1	268*	252	248
		Sorghum ..	2	316**	240	268
		N and K re-applied				

Note.—Strong foliar symptoms of P deficiency were apparent on N treated plots in the L.R. 1953 crop.

Centre Altitude and Soil	Season and Rainfall during growth Yield units	Crop Fertilizer Treatment	Level	Yield Data: Fertilizer		
				N	P	K
Matuga—(*Contd.*)	S.R. 1953. 6·93 in. lb. grain/acre	Green Gram Residual ..	0 1 2	172 175 187	164 180 190	174 178 181
	L.R. 1954. cwt. wilted fodder/acre: total of 3 cuts	Guinea grass N, P and K reapplied	0 1 2	50·8 49·7 61·9	43·6 59·3** 57·5**	46·6 52·1 61·8**
Embu 4,800 ft. Kikuyu dark red loam	L.R. 1952.	Panicum mileacium N, P and K applied		Very variable crop: no yield data obtained		
	S.R. 1952. 10·69 in. lb. grain/acre	Beans .. Residual ..	0 1 2	540 676* 601	594 599 624	650 580 587
	L.R. 1953. 25·76 in. lb. grain/acre	Maize N, P and K reapplied	0 1 2	2852 3292 3032	2404 3068** 3480**	3224 2900 2932
	S.R. 1953. 14·43 in. lb. grain/acre	Bulrush millet Residual ..	0 1 2	1771 1958 1818	1606 1778 2162**	1921 1796 1828
	L.R. 1954. 34·30 in. lb. grain/acre	Maize .. N and K re-applied ..	0 1 2	5151 5366 5367	4838 5407** 5640**	5299 5341 5244
	S.R. 1954. 14·64 in. lb. grain/acre	Beans .. Residual ..	0 1 2	1144 1200 1172	1060 1164 1292**	1160 1160 1192
Kampi ya Mawe 3,700 ft. Red Plains soil	L.R. 1952.	Maize N, P and K applied		Results destroyed: effects were small		
	S.R. 1952. lb. grain/acre	Bulrush millet N, P and K reapplied	0 1 2	1000 1028 1068	672 1168** 1260**	1068 968 1060
	L.R. 1953. lb. grain/acre	Bulrush millet Residual	0 1 2	324 320 276	282 301 337	284 316 360
	S.R. 1953. lb. grain/acre	Bulrush millet N and K re-applied	0 1 2	1076 1198 1303*	836 1364** 1376**	1216 1088 1276
	L.R. 1954. lb. grain/acre	Dwarf Hegari .. Sorghum N and K re-applied	0 1 2	2401 2382 2530	2140 2464 2704*	2414 2399 2500

Centre Altitude and Soil	Season and Rainfall during growth Yield units	Crop Fertilizer Treatment	Level	Yield Data: Fertilizer		
				N	P	K
Makaveti 4,900 ft. Makaveti red loam	L.R. 1952. 13·67 in. lb. grain/acre	Maize .. N, P and K applied	0	426	492	444
			1	514	411	465
			2	455	492	485
	S.R. 1952. lb. grain/acre	Bulrush millet N, P and K reapplied	0	263	149	322
			1	328	343**	309
			2	316	414**	276
	L.R. 1953. lb. green fodder/acre	Maize .. N and K re-applied	0	358	160	278
			1	237	241	197
			2	103*	330*	223
				Crop planted late: fodder weights taken, little grain set.		
	S.R. 1953. lb. grain/acre	Beans .. Residual ..	0	594	558	645
			1	707*	675*	681
			2	674	742*	649
	L.R. 1954. lb. grain/acre	Maize .. N reapplied	0	1704	1417	1784
			1	1723	1850**	1721
			2	1834	1995**	1757

Notes—

(1) No significant interactions were observed in any of these trials.

(2) Yields marked * are significantly different from the corresponding "no fertilizer yield" at the 5 per cent point.

(3) Yields marked ** are significantly different from the corresponding "no fertilizer yield" at the 1 per cent point.

(4) In all trials at each time of application, nitrogen was applied as sulphate of ammonia at 0, 1 and 2 cwt., P as double supers at 0, 1 and 2 cwt., and K as muriate of potash at 0, $\frac{1}{2}$ and 1 cwt., per acre, these rates of application corresponding with the 0, 1 and 2 levels of each described in the table.

Despite quite heavy applications of N and K at least once each year, on few occasions were these fertilizers beneficial. Phosphate application both placed and broadcast gave consistent benefits during the season of application and frequently gave benefits in subsequent seasons. Most crops tried benefited from the phosphate application, but the relative magnitude of the responses showed pronounced seasonal variations. In particular, residual effects were insignificant mainly in seasons when the level of yield generally was low. The seasonal factor which determined the general level of yield and the phosphate response was local in operation, the responses differing widely from centre to centre each season. The data contains the suggestion that the benefits of phosphate application continued to increase with increasing rate of application to a considerably higher level at Embu (where rainfall is reliable and well distributed) than at the other centres (where rainfall is unreliable and badly distributed). At Matuga, Kampi ya Mawe and Makaveti, 1 cwt. double supers per acre seems the highest rate of application to which it is worth going, while on those crops which respond to fertilizers at Embu, there is ample justification for applying double supers at as high a rate as 2 cwt. per acre. At Kiberani on a neutral soil derived from Lagoonal sands, N and P responses were recorded for the first time on a good crop of sorghum on land which had received two consecutive years of fertilizer application.

Lime—Fertilizer Experiments

The two experiments laid down in 1953 at Kaptagat and Eldoret were continued during 1954, and two further trials were begun at Marindas and South Kinangop.

(1) KAPTAGAT

Treatments.—L_0, no lime; L_1, 4,600 lb. ground dolomite limestone per acre; L_2, 10,260 lb., ditto; L_3, 18,000 lb., ditto; M, 16,000 lb. calcitic limestone; H, 9,300 lb. lime whitewash; P_0, no phosphate; P_1, 100 lb. double superphosphate per acre; P_2, 200 lb., ditto; P_3, 400 lb., ditto; K, 200 lb. muriate of potash per acre; N, 200 lb. sulphate of ammonia per acre. Planted to wheat June, 1953. Harvested December, 1953.

GRAIN AS POUNDS PER ACRE (1953)

	L_0	L_1	L_2	L_3	M	H	Mean
P_0	777	859	774	943	690	861	817
P_1	994	1122	1157	1136	852	1092	1059
P_2	1139	1115	1307	1293	1055	1165	1179
P_3	1274	1263	1264	1281	1149	1212	1241
Mean	1046	1090	1126	1163	937	1083	

with N	1084
without N ..	1063
with K	1197
without K ..	950

Nitrogen had no effect. None of the lime treatments had any significant effect. Phosphate caused a highly significant increase in yield, all levels giving a higher yield than the preceding lower level. Potash also gave a highly significant increase in yield.

STRAW AS POUNDS PER ACRE (1953)
(*mean yields only are given in this table*)

L_0	L_1	L_2	L_3	M	H
1852	1938	2069	2226	1790	2133

P_0	P_1	P_2	P_3	without K	with K	without N	with N
1388	1875	2193	2550	1855	2146	1922	2099

RATIO GRAIN : STRAW (1953)

L_0	L_1	L_2	L_3	M	H
0·57	0·57	0·55	0·53	0·53	0·51

P_0	P_1	P_2	P_3	without K	with K	without N	with N
0·59	0·57	0·54	0·49	0·51	0·56	0·53	0·54

Lime and phosphate appear to have encouraged growth of the straw relative to the grain. Potash has had the opposite effect and nitrogen no effect.

Nitrogen, phosphate and potash were reapplied at the initial rates in 1954. Wheat was planted in May, 1954, and harvested in January, 1955.

GRAIN AS POUNDS PER ACRE (1954)

	L_0	L_1	L_2	L_3	M	H	Mean
P_0	1008	1442	1753	2215	2300	1810	1755
P_1	2092	2319	2516	2168	2460	2470	2337
P_2	2215	2149	2083	1678	1791	2281	2033
P_3	2074	1960	1593	1565	1631	2083	1818
Mean	1847	1968	1986	1907	2046	2161	

with N	1916
without N ..	2055
with K	2107
without K ..	1863

The results have not been statistically analysed, but again there appears to have been a response to phosphate and potash, and on this second crop, to lime. Severe lodging occurred on plots given the higher levels of phosphate, and yields involving these treatments and the means should be treated with reserve.

STRAW AS POUNDS PER ACRE (1954)

L_0	L_1	L_2	L_3	M	H
4458	4838	5024	4913	4913	5133

P_0	P_1	P_2	P_3	without K	with K	without N	with N
3899	5288	5388	4931	4673	5073	4723	5022

Although the higher phosphate levels caused severe lodging, they do not appear to have increased the yield of straw. The straw was carefully collected and the above figures may be taken as substantially correct.

RATIO GRAIN : STRAW (1954)

L_0	L_1	L_2	L_3	M	H
0·41	0·41	0·39	0·39	0·42	0·42

P_0	P_1	P_2	P_3	without K	with K	without N	with N
0·46	0·44	0·38	0·37	0·40	0·42	0·44	0·38

In 1954, a year of better rainfall than 1953, the mean ratio of grain to straw was considerably less and the effect of lime and fertilizers was apparently less marked.

Effect on Soil pH

Soil samples (0–8 in.) were taken at harvesting six months after the application of lime. The mean values, using a 1 : 1 soil-water ratio, were: —

L_0	L_1	L_2	L_3	M	H
4·64	4·83	5·09	5·45	5·42	5·12

A few plots were sampled at 8–16 in. but the limed plots showed no increase over the control plot mean of 4.77.

Grain and Leaf Analysis

Samples of grain were taken from all plots of the 1953 crop at harvesting. Samples from one of the two replications were milled, oven dried at 105°C. and total phosphate estimated on samples from the calcitic limestone plots.

PERCENTAGE PHOSPHATE IN WHEAT (AS P ON OVEN DRY MATERIAL)

	L_0	L_1	L_2	L_3	Mean
P_0	0·245	0·264	0·275	0·271	0·264
P_1	0·253	0·249	0·269	0·271	0·261
P_2	0·251	0·271	0·267	0·294	0·271
P_3	0·286	0·288	0·298	0·340	0·303
Mean ..	0·259	0·268	0·277	0·294	

Both lime and superphosphate appear to have increased the phosphate content of the grain, especially at the higher levels of application.

Leaf samples were taken from the 1954 crop just prior to flowering and determination of total phosphate, calcium, magnesium and potash were made on the oven-dried material.

PERCENTAGE PHOSPHATE (AS P) IN LEAF

	L_0	L_1	L_2	L_3	M	H	Mean
P_0	0·232	0·236	0·264	0·269	0·266	0·269	0·256
P_1	0·266	0·270	0·268	0·266	0·282	0·265	0·270
P_2	0·268	0·268	0·270	0·272	0·263	0·268	0·269
P_3	0·273	0·266	0·279	0·289	0·273	0·270	0·275
Mean	0·260	0·260	0·270	0·274	0·272	0·268	

Both lime and superphosphate have slightly increased the phosphate content of the leaf.

The application of potash appears to have had a marked influence on the mineral composition of the leaf.

POTASH CONTENT OF LEAF (AS K)

Without KCl fertilizer .. 3·00 per cent

With .. .. .. 3·34 per cent

Calcium Content of Leaf (as Ca)

	L_0	L_1	L_2	L_3	M	H	Mean
Without K ..	0·329	0·463	0·518	0·710	0·548	0·566	0·522
With K.. ..	0·209	0·218	0·369	0·423	0·405	0·387	0·335
Mean	0·269	0·341	0·444	0·567	0·477	0·477	

All forms and rates of lime have greatly increased the calcium content of the leaf. Potash application has had a marked effect in decreasing the leaf calcium at all rates of lime application.

Magnesium Content of Leaf (as Mg)

	L_0	L_1	L_2	L_3	M	H	Mean
Without K ..	0·184	0·167	0·178	0·200	0·145	0·176	0·175
With K.. ..	0·122	0·123	0·124	0·138	0·110	0·118	0·123
Mean	0·153	0·145	0·151	0·169	0·128	0·147	

Only the highest application of dolomitic limestone has increased the magnesium content of the leaf, whilst calcitic limestone has decreased it. Potash application has markedly decreased leaf magnesium.

Field observations indicated that plants on the potash plots were less infected with leaf rust than those on the no potash plots. In this connexion the following excerpt is quoted from the U.S.D.A. Year Book for 1953: "Potassium salts in moderate amounts increase the resistance of wheat to leaf rusts. Moderately resistant varieties may be made susceptible by depriving them of potassium".

(2) Eldoret

Treatments (the letters L, M, N, P and K have the same significance as in Experiment No. 1).—L_0, nil; L_1, 6,860 lb.; L_2, 11,000 lb.; M, 6,150 lb.; P_1, 100 lb.; P_2, 200 lb.; N, 200 lb.; K, 200 lb. Planted to wheat July, 1953. Harvested December, 1953.

Grain as Pounds per Acre (1953)

	L_0	L_1	L_2	M	Mean
P_0	226	264	286	298	269
P_1	362	438	363	389	388
P_2	368	381	329	418	374
Mean ..	319	361	326	368	

Nil	With K	With NK
297	365	371

The lower levels of lime, both calcitic and dolomitic, gave comparable results which were significantly better than the control yield and the yield from plots receiving the higher dressing. Phosphate gave highly significant increases in yield, but no significant difference between the two levels. Potash caused a highly significant increase in yield, but the further addition of nitrogen caused no increase.

STRAW AS POUNDS PER ACRE (1953)

(*mean yields only are given in this table*)

L_0	L_1	L_2	M			
1394	1674	1570	1648			
P_0	P_1	P_2		O	K	NK
1219	1692	1804		1504	1584	1622

Both lime and phosphate have increased the yield of straw, but as for the grain yields, the yield from the high-level lime plots is less than from the low-level plots.

RATIO GRAIN : STRAW (1953)

L_0	L_1	L_2	M			
0·22	0·22	0·22	0·23			
P_0	P_1	P_2		Nil	With K	With NK
0·22	0·23	0·22		0·20	0·23	0·23

The low rainfall during the growing season is reflected in the narrow grain-straw ratio. Phosphate and lime have had little if any effect on the ratio. Potash appears to have encouraged the yield of grain relative to that of the straw.

Nitrogen, phosphate and potash were reapplied at the initial rates in 1954. Wheat was planted in June, 1954.

Effect on Soil pH

Method as for Experiment No. 1.

	Time Interval	L_0	L_1	L_2	M
1953 ..	5 months	4·94	5·80	5·97	5·78
1954 ..	17 months	5·08	5·86	6·21	6·04

The greatest activity of the lime appears to have been exerted in the first six months, only a slight change being shown in the following 12 months.

(3) MARINDAS

Design.—4 × 4 × 2. Two replications.

Treatments.—L_0, nil; L_1, 8,300 lb.; L_2, 15,000 lb.; M, 7,400 lb.; P_1, 100 lb.; P_2, 200 lb.; P_3, 400 lb.; N, 200 lb.; K, 200 lb. Planted to wheat, mixed with red clover in June, 1954. Harvested January-February, 1955.

GRAIN AS POUNDS PER ACRE (1954)

	L_0	L_1	L_2	M	Mean
P_0	426	868	921	894	777
P_1	896	1496	1756	1688	1459
P_2	1547	2051	1842	1824	1816
P_3	1772	1840	2196	1848	1914
Mean ..	1160	1564	1679	1564	

Without NK	With NK
1429	1554

Phosphate has had a striking effect and lime a smaller effect on yield, the responses tailing off at the higher levels of application. There are indications of a small response to the combined N/K dressing.

STRAW AS POUNDS PER ACRE (1954)

(*mean yields only are given in this table*)

L_0	L_1	L_2	M
3726	4549	4721	4568

P_0	P_1	P_2	P_3	Without NK	With NK
2311	4037	5198	6018	4300	4480

RATIO GRAIN : STRAW (1954)

L_0	L_1	L_2	M
0·31	0·34	0·36	0·34

P_0	P_1	P_2	P_3	Without NK	With NK
0·34	0·36	0·35	0·32	0·33	0·35

(4) KINANGOP

Design.—As for Experiment No. 3.

Treatments.—L_0, nil; L_1, 3,400 lb.; L_2, 6,000 lb.; M, 3,000 lb.; N, P and K, as for Experiment No. 3. Planted to barley September, 1954. Harvested March, 1955.

GRAIN AS POUNDS PER ACRE (1954)

	L_0	L_1	L_2	M	Mean
P_0	143	171	153	207	169
P_1	650	764	788	754	739
P_2	854	864	993	994	926
P_3	974	897	817	990	920
Mean ..	655	674	688	736	

Without NK	With NK
693	683

On this land, broken in 1952, and given its first fertilizer application in 1954, there has been a marked response to 100 lb. superphosphate but this tails off at the higher rates. Lime has had little effect. There has been no response to the N/K treatment on this site, probably due to the late application—three months after planting.

Owing to late harvesting, the straw from these plots was not collected and weighed.

Organic Matter Studies on Soils of the Kenya Highlands

Further samples of soil (0–8 in.) were taken during the year from farms in the Trans Nzoia district. Organic carbon (Walkley Black), total nitrogen and pH (1 : 1 soil-water ratio) determinations were made. The results obtained were combined with those presented in the previous report, and a summary for each district is given below. In this report all Walkley Black carbon values have been adjusted to total organic carbon values on the basis of 78 per cent recovery found for soils in the Njoro district. Figures in brackets refer to the number of fields sampled to obtain the mean values given. The fields sampled were grouped into three classes: virgin, cultivated and ley or reversion to grass after cultivation. Owing to the varying periods of time under cultivation or grass and lack of details in many instances, it is not possible to give average periods.

District	Class	pH	C	N	C/N	PER CENT LOSS ON INITIAL VALUES	
						C	N
Trans Nzoia	Virgin (6)	5·78	3·06	0·180	17·0		
Trans Nzoia	Cultivated (8).. ..	5·68	2·53	0·158	16·0	17	14
Trans Nzoia	Cultivated—grass (11)	5·76	2·31	0·142	16·3	24	21
Njoro ..	Virgin (1)	5·79	4·40	0·251	17·5		
Njoro ..	Cultivated (5).. ..	5·74	3·90	0·226	17·3	11	10
Njoro ..	Cultivated—grass (5)	5·93	4·55	0·258	17·6	3	+3
Menengai ..	Virgin (1)	5·67	4·04	0·253	16·0		
Menengai ..	Cultivated (4).. ..	5·64	3·21	0·198	16·2	21	22
Menengai ..	Cultivated—grass (2)	5·71	3·48	0·220	15·8	14	13
Ol Joro Orok	Virgin (2)	5·48	4·05	0·313	12·9		
Ol Joro Orok	Cultivated (3).. ..	4·95	3·57	0·231	15·5	12	26
Ol Joro Orok	Cultivated—grass (2)	5·58	3·85	0·318	12·1	5	+2
S. Kinangop	Virgin (2)	5·08	2·89	0·218	13·3		
S. Kinangop	Cultivated (3).. ..	5·13	2·61	0·218	12·0	10	Nil
Molo ..	Virgin (2)	5·34	5·21	0·309	16·9		
Molo ..	Cultivated (4).. ..	5·29	4·88	0·322	15·2	6	+4

NOTE.—Approximate altitudes are: Trans Nzoia 6,500 ft. Njoro 7,000 ft. Ol Joro Orok 7,800 ft. South Kinangop 8,500 ft. Molo 9,000 ft.

MEAN VALUES FOR ALL DISTRICTS

	pH	C	N	C/N	PER CENT LOSS ON INITIAL VALUES	
					C	N
Virgin	5·52	3·94	0·254	15·5	12	11
Cultivated	5·41	3·45	0·226	15·3		

Fields carrying grass after cultivation were not sampled at Molo and South Kinangop, and mean values are given in the following table for the three classes in the four other districts:—

	pH	C	N	C/N	PER CENT LOSS ON INITIAL VALUES	
					C	N
Virgin	5·68	3·89	0·249	15·6		
Cultivated	5·50	3·30	0·203	16·2	15	19
Cultivated—grass ..	5·75	3·55	0·235	15·1	9	6

Owing to the scanty cultivation history of some fields and the difficulty in some instances of finding comparable neighbouring fields for comparison, it is difficult to give a clear picture of the loss of organic matter on cultivation and the build up on reversion or planting to grass.

The carbon and nitrogen values, even on the rather sandy soils of the Trans Nzoia and the pumice soils of Menengai may be considered high for uncultivated tropical soils. A general direct relationship is shown, with the exception of the Kinangop soils, between carbon and nitrogen values and elevation. The C/N ratio shows little relationship to either soil pH or elevation and is generally higher than that found in temperate lands.

The mean values given in the last table show a slight drop in pH on cultivation and an increase when grass follows cultivation. On cultivation the carbon shows an average decrease of 15 per cent and nitrogen of 19 per cent, but these deficits are reduced to 9 per cent and 6 per cent respectively when grass follows cultivation. The extent of these changes appears to be influenced by soil type and perhaps by elevation. The drop in carbon content is greatest on the lighter soils of Trans Nzoia and Menegai and the build-up following grass appears to be less marked in these districts. The apparent failure of grass to improve the carbon and nitrogen contents in the Trans Nzoia may be ascribed to the inclusion of two fields under cultivation for long periods, 20 and 27 years—and under following grass for two and three years respectively. At sampling time the losses based on the virgin soil were 39 per cent C, and 30 per cent N, and 42 per cent C, and 44 per cent N respectively. On the greyish silty loam of the Kinangop, the losses of organic matter appear to be relatively small, but the fields sampled had been under cultivation for a very short time, one and two years. At Molo (9,000 ft.), on a reddish brown loam, two fields under cultivation for 15 years showed losses of only 13 per cent and 8 per cent C, and of 5 per cent, and nil of N respectively.

SOIL SURVEYS

In collaboration with E.A.A.F.R.O., preliminary classifications of the soils of Nyanza Province and of the western part of Nakuru district were completed. Meanwhile, some progress was made by a good number of field officers in the

mapping of the more easily recognizable soils of their districts, and officers of E.A.A.F.R.O. have carried out detailed surveys of the various Government farms at Kitale. However, the progress which has been possible and the assistance given to these activities had to be curtailed severely during the year on account of the need which arose to intensify investigation of areas which presented possibilities for African settlement. Irrigation projects particularly, within the Tana River drainage area, received the most detailed attention.

An aerial survey of the Mwea and Tebere project areas was undertaken, and contour maps of Tebere on a scale of 1/5,000 based on the aerial survey became available during the year. Based on these maps, a detailed soil survey was undertaken at Tebere and those areas deemed suitable for upland crops, those suitable for rice and those too shallow to irrigate were determined and demarcated. The soils for which rice growing is projected are uniform black clay loams with scattered calcareous concretions in the subsoil, abruptly changing to weathering volcanic rock at usually between 2 ft. and 4 ft. depth. They occur characteristically in broad depressions and on flat land. The soils for which upland crops are projected are uniform red, brown or dark grey-brown loams usually deep but locally less than 4 ft. over earthy laterite. These soils occur on the ridges and slopes which together with rocky escarpments are the main local geographical features. Where the ridges and slopes are least perceptible the black soils and the upland crop soils merge barely perceptibly one with the other. Recent land utilization in this area has been influenced strikingly by the soils. The upland soils, being easily cultivable, have been closely and continuously cropped with rain-grown African subsistence crops even though local rainfall is extremely uncertain and crop failures are common. Patches of cultivation occur even within black soils areas where barely perceptible local relief is associated with the development of incipient upland crop soils characteristics. The heavy black soils are much less tractable, and were virtually unused until, recently, local cultivators discovered that this soil can be handled as it dries out at the end of the rainy season and that its moisture content then is adequate to carry a profitable crop of chick pea through to maturity: the consequence has been the planting of quite considerable areas of chick pea, at least where the black clays merge with the upland soils. The contrasting topographical and agronomic characteristics of the black clays and the upland crop soils are so strong that except in areas where the two soils merge least perceptibly one with the other, delimitation of their boundaries by reference to contour distribution and land use indications on the aerial survey maps was found by field verification to be accurate.

Reconnaissance surveys of irrigation possibilities in Northern Kitui, based on the Tana River and in the Barsalinga area of Samburu District, based on the Uaso Nyiro River were also carried out. These confirmed the existence of extensive broad ridges of black clay loam of high chemical fertility at the Kitui site and revealed the existence of undulating country with red sandy loam soils of variable, usually shallow depth at the Samburu site. Topography within these areas and the engineering aspects of the diversion of water on to them proved extremely unfavourable so further consideration of projects for development there has been deferred. The production potential of the Kitui site is considered much greater than that of the Samburu site.

Lands commanded by the Lower Tana were further surveyed, the possibility of irrigating desert land remote from the flood plain of the river and of irrigating land at the head of the delta receiving particular attention. These investigations confirmed that the soils of the late Tertiary Peneplain which form the desert are saline, alkaline soils of low permeability. In pot culture trials on representative soils from the desert hinterland it was established that these soils have a low crop

production potential. However, the engineering difficulties attached to alternative projects based on the Lower Tana are so great that investigations into the possibility of cropping the desert soils are continuing.

The soils within the flood plain are mainly clay loams of good fertility traversed by bands of more sandy but still fertile land probably along the lines of old river channels. Drainage within the flood plain is satisfactory in the higher regions, but tends to deteriorate (and the soils tend to become greyer) as the delta is approached. Within the delta, older banks of less fertile, sandy soils occur locally.

Nitrogen Studies

Determination of the ammonia/nitrogen content of rainwater collected at Scott Agricultural Laboratories was continued. The results from daily collections were:—

Rainfall	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
N added by rain ..	1·40	3·82	0·11	9·84	14·36	1·67	1·58	0·31	0·32	1·25	5·12	1·05
lb./acre	·055	·466	·022	·817	1·033	·110	·077	·009	·010	·221	·737	·106
lb./acre per in. of rain	·039	·122	·018	·083	·072	·066	·049	·029	·032	·177	·144	·101

Total Addition of Ammoniacal N

Lb./acre, 3.64. Lb/acre per inch of rainfall, .088.

Lb./acre per inch of rainfall (mean for 5 years), .079.

Marked seasonal variation in content once again was apparent. An examination of the data accumulated over the past five years was carried out to determine whether this variation was in any way connected with the quantity of rain falling each day, and whether any simple relationship existed between quantity of rainfall and ammoniacal content. The correlation coefficient between daily rainfall and ammoniacal nitrogen content for the 353 separate observations studied was 0.125 only, and this failed to reach significance at the 5 per cent point. It seems that the ammoniacal content of nitrogen in rain does not vary appreciably with the quantity of rain falling, at least for falls of up to 3.45 in. in 24 hours (which was the highest fall in the data examined). Thus there is no indication of heaviness of rainfall being implicated in the marked seasonal variation in content which has been observed, and there is no indication that the first flush of rain on each rainy day flushes the atmosphere free from the accumulation of ammonia which, according to the evidence of Ingham (*Soil Science*, 70 (1950), 205–213), the air contains.

Njoro Pumice Soils

Introduction.—It has been found in the field that applications of phosphate reduce yields and induce adverse crop symptoms, namely die-back from the leaf tips and leaf blade mottling, and defective grain formation. Evidence has previously been obtained that crops showing such symptoms are responsive to copper, but copper does not appear to be the only factor involved.

Experimental.—An experiment designed to investigate the effect of copper, zinc and phosphate was performed, using wheat grown in pots. This was a 3 × 3 × 2 factorial experiment in three replicates with copper sulphate applied at rates equivalent to 0, 40 and 200 lb./acre, zinc sulphate at the same rates, and double supers at 0 and 140 lb./acre was performed with a soil typical of the area, wheat being employed as a test crop.

Results.—Growth was generally poor and leaf symptoms appeared to be unaffected by the trace elements employed. Grain formation was, however, markedly stimulated by the application of copper.

YIELD DATA

(*a*) *Grains Per Plant*

MEANS OF MAIN EFFECTS

Cu_0	Cu_{40}	Cu_{200}	L.S.D.	Significance
0	12·7	15·8	8·6*	$Cu_{200} > Cu_0$*** $Cu40 > Cu_0$**
Zn_0	Zn_{40}	Zn_{200}	11·6**	
8·5	11·6	8·5	15·4***	
P_0	P_{140}		7·0*	$P_{140} > P_0$*
5·6	13·4		9·5**	

TWO-WAY TABLES OF MEANS

	P_0	P_{140}		P_0	P_{140}	Cu_0	Cu_{40}	Cu_{200}	L.S.D. for 3×2 Tables	L.S.D. for 3×3 Table
Cu_0	0	0	Zn_0	6·3	10·6	0	19·0	6·3	12·2*	14·9*
Cu_{40}	4·2	21·2	Zn_{40}	8·5	14·8	0	9·5	25·4	16·4**	20·1**
Cu_{200}	12·7	18·9	Zn_{200}	2·2	14·8	0	9·5	15·8	21·8***	26·8***

(*b*) *Dry Matter Produced per Plant* (*Mg.*)

MEANS OF MAIN EFFECTS

Cu_0	Cu_{40}	Cu_{200}	L.S.D.	Significance
586	683	643	68*	$Cu_{40} > Cu_0$**
Zn_0	Zn_{40}	Zn_{200}	92**	
638	613	663	121***	
P_0	P_{140}		56*	$P_{140} > P_0$*
609	667		75**	

TWO-WAY TABLES OF MEANS

	P_0	P_{140}		P_0	P_{140}	Cu_0	Cu_{40}	Cu_{200}	L.S.D. for 3x2 Tables	L.S.D. for 3x3 Table
Cu_0	577	595	Zn_0	606	669	637	629	644	97*	118*
Cu_{40}	654	711	Zn_{40}	585	639	508	676	654	130**	159**
Cu_{200}	595	692	Zn_{200}	635	690	610	744	634	172***	210***

Discussion.—The results show copper to be beneficial both in the formation of grain and in the production of dry matter. A level of about 40 lb./acre would appear to be adequate. Zinc had no overall effect. Copper and phosphate together produced the highest yields of grain and dry matter, the treatment combination Cu_{40} P_{140} giving maximal yields. The experimental results are suggestive of an acute copper deficiency in these soils, but no evidence has been obtained of a zinc deficiency.

It is likely that some other minor element is involved since neither copper nor zinc cures the visual crop symptoms, and even in the presence of copper many empty heads are formed.

Studies on Copper Fixation

Copper sulphate at rates equivalent to 0, 40 and 200 lb./acre was added to soil: water suspensions at pH 6.23 (natural pH of the soil) 5.23 and 4.23. After standing with occasioanl shaking for 36 hours, the pH of the suspension was adjusted to pH 2.0 with hydrochloric acid and the copper was extracted and estimated by the procedure of Steenjberg and Boken (1950).

The accompanying table shows the amounts of copper extracted from the suspensions and the degree of copper fixation:—

Copper added lb. $CaSO_4.5H_2O$/acre	pH of suspension	Copper extracted ppm (air dry soil basis)	Copper fixed per cent
0	6·23	0·03	—
40	6·23	0·35	93·8
200	6·23	3·90	24·3
0	5·23	0·03	—
40	5·23	0·38	93·2
200	5·23	3·70	27·3
0	4·23	0·02	—
40	4·23	0·38	93·0
200	4·23	2·70	47·6

Steenjberg and Boken's (1950) limits of available soil copper when recalculated from TC_u to ppm are as follows:—

Crop Symptoms	ppm Cu in Air Dried Soil
Severe Deficiency ..	0·081
Deficiency	0·158
Normal Crop	0·752

The results of this study would indicate that a dressing of 40 lb. of copper sulphate per acre greatly relieves the soil copper deficiency, and that the optimal dressing would slightly exceed this figure; a graphical solution suggests about 70 lb./acre. Statistical examination unexpectedly showed pH to be without significant effect upon copper availability and fixation, and it may well be that, under field conditions, a more normal behaviour would obtain.

Studies on soil copper availability have confirmed the results of pot experiments, and have revealed a gross copper deficiency in the soil. Yield data from the pot experiments suggests that the optimum rate of application of copper sulphate lies between 40 and 200 lb./acre. A very tentative figure obtained from studies on copper fixation and availability is 70 lb./acre.

References.—Steenjberg, F., and Boken, E. (1950). *Plant and Soil 2*, 195.

Embu Bracken Soils

Two parallel series of pot experiments were performed to investigate the possibility of manganese and/or aluminium toxicity in these soils (pH 4.2). Beans (*Phaseolus vulgaris*) were employed as the indicator crop, for previous work by Löhnis (1951) had shown this crop to be a suitable indicator of manganese toxicity, due partly to the easily recognizable visual symptoms and partly to the well defined threshold value of leaf manganese above which toxicity symptoms were apparent. Aluminium toxicity symptoms for the dwarf bean have been described by Hewitt (1948).

EXPERIMENTAL

(a) Sand Cultures

In order to gain quantitative information of the effect of manganese and aluminium toxicities on beans, the following experiment in sand cultures was performed.

Treatments.—The following treatments were employed in four replications:—

(i) Basal nutrients.

(ii) Basal nutrients + excess manganese.

(iii) Basal nutrients + excess aluminium.

(iv) Basal nutrients + excess manganese and aluminium.

Nutrient Solutions.—The solutions employed in this work were based upon Hewitt's (1947, 1948) solutions and were adjusted to pH 4.2 by the addition of half normal sulphuric acid. Stabilization of pH was effected by the method of Trelease and Trelease (1933). The solutions had the following composition:—

	Basal	Excess Manganese	Excess Aluminium	Excess Manganese Manganese and Aluminium
	M.E/1	M.E/1	M.E/1	M.E/1
$Ca(NO_3)_2$ ..	1·5	1·5	1·5	1·5
KNO_3	3·0	3·0	3·0	3·0
$NaNO_3$	1·0	1·0	1·0	1·0
$(NH_4)_2SO_4$ ..	5·5	5·5	5·5	5·5
NaH_2PO_4 ..	2·0	2·0	2·0	2·0
$MgSO_4$	3·0	3·0	3·0	3·0
$MnSO_4$	0	2·0	0	2·0
$Al_2(SO_4)_3$ ..	0	0	4·0	4·0
H_2SO_4	0·7	0·8	0·05	0·05

The pots were covered with a 1 cm. layer of silver-coated sand to prevent algal growth, and the nutrients were renewed daily.

(*b*) *Soil Cultures*

To obtain information on whether crop failure was due to toxic levels of soil manganese or aluminium, a technique similar to that of Löhnis (1951) was employed.

Treatments.—The following treatments were employed in three replications: —

(i) No treatment.

(ii) Lime.

(iii) Lime + manganese.

(iv) Lime + aluminium.

(v) Lime + manganese + aluminium.

In the limed series the theoretical amount of calcium hydroxide to give a soil pH of 6.0 was added (3.35 tons $Ca(OH)_2$ per acre). Manganese and aluminium were applied as sulphates; the additions corresponding to 1,845 lb. of the salts per acre. (This rate of addition of manganese sulphate was employed by Löhnis (1951).)

Results.—The beans grown in the basal nutrient showed normal growth, flowering and seed formation. Leaf symptoms of manganese toxicity followed closely those described by Hewitt (1948), and Löhnis (1951). Flower buds were formed but failed to develop. The leaf symptoms associated with manganese toxicity were accentuated in the presence of toxic levels of aluminium. Symptoms of aluminium toxicity were slight; the leaves had a somewhat darker colour and the development of the flower buds was only slightly reduced.

The beans grown in soil in general made very poor growth. The visual appearance was suggestive of neither manganese nor aluminium toxicity.

YIELD DATA

(*a*) *Sand Cultures*

TREATMENT MEANS

Treatment	Pods per Plant	Pod Weight (g)	Beans per Plant
I 0	7·00	13·70	28·00
II +Mn	0·00	0·00	0·00
III +Al	5·25	10·05	13·75
IV +(Mn, Al) ..	0·00	0·00	0·00
Coefficient of Variation	35·02	27·00	88·52
Significance ..	(I, III)> (II, IV)***	(I, III)> (II, IV)*** I> III*	I> (II, IV)***

(b) Soil Cultures

TREATMENT MEANS

Treatment	Pods per Plant	Pod Weight (g)	Beans per Plant
I 0	2·00	0·70	9·33
II Ca	5·33	3·67	24·67
III Ca+Mn ..	3·67	2·43	13·00
IV Ca+Al	6·67	1·97	29·00
V Ca+(Mn, Al) ..	5·33	2·10	18·33
Coefficient of Variation	29·00	24·08	25·08
Significance ..	(II, V)> I* IV> I** IV> III*	IV>I* , II> III* II>I***II> (IV, V)** (III V)> I**	V> I*, II> III* II> I**IV> III** IV> I***V> IV*

ANALYTICAL DATA ON THE LEAVES OF BEANS GROWN IN SOIL

Treatment	N %	P %	K %	Ca %	Mg %	Mn ppm
I 0	3·48	0·320	2·20	0·03	0·218	881
II Ca	4·43	0·257	1·74	1·72	0·284	269
III Ca+Mn	3·89	0·271	1·62	2·10	0·293	729
IV Ca+Al	3·88	0·298	0·91	1·66	0·262	403
V Ca+(Mn, Al) ..	3·08	0·327	1·59	1·92	0·251	987
Coefficient of Variation ..	19·56%	24·91%	34·75%	25·57%	15·99%	16·64%
Significance	not sig.	not sig.	I> IV**	(II, V)> I***	not sig.	(I, V)> (II, IV)***

The manganese content of the leaves of beans grown in sand cultures is given in the accompanying table:—

TREATMENT MEANS PPM MN				Coefficient of Variation	Significance
Basal	+Mn	+Al	+Mn Al		
646	2850	750	2051	22·47%	II, IV> I, III***, II> IV*

The highest value of leaf manganese found for a plant not affected by manganese toxicity was 814 ppm Mn and the corresponding lowest value for a plant affected by manganese toxicity was 1470 ppm Mn. The threshold value at which leaf symptoms will become apparent clearly lies between these two values.

Analytical Data on Soils

Treatment Means

Treatment	pH	P lb/acre	Ca lb./acre	Mg lb/acre
I 0	4·60	20	887	55
II Ca—	6·05	11	4,297	75
III Ca+Mn	5·77	23	4,480	57
IV Ca+Al	5·73	13	2,493	59
V Ca+(Mn, Al) ..	5·58	17	4,847	52
Coefficient of Variation ..	0·66%	45·91%	79·91%	22·97%
Significant Differences ..	II> (I, III, IV)*** (III, IV)> V*** (III, IV, V)> I***	None	None	None

pH was determined in a 1:2.5 soil:water suspension, and plant nutrients were determined by the rapid methods described by Wolf (1943), in which extraction is performed with Morgans Reagent, and a soil : extractant ratio of 1 : 2 is employed.

Discussion.—Liming was found to exert a beneficial effect upon the formation of pods and beans, and upon the pod weight. The very low level of calcium in the leaves of beans grown in the soil which had received no treatment is indicative of calcium deficiency as such. Visual symptoms of manganese or aluminium toxicity were not observed in any of the plants grown in soil, and the levels of manganese in the leaves were also not suggestive of manganese toxicity. The addition of manganese and aluminium in the presence of lime were not sufficient to produce the visual symptoms associated with toxic levels of these elements, but yields were, however, slightly depressed. It is possible therefore that the effect of lime is twofold, and that its beneficial action results partly in the correction of a calcium deficiency in the soil and partly in its antagonistic action towards manganese and aluminium. Further work on these soils is necessary to determine the optimum dressing of lime under field conditions, and the optimum dressings of plant nutrients whether in the form of inorganic salts or in the form of organic manures.

References

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Löhnis, M. P. (1951). *Plant and Soil, 3,* 193–222.

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In a subsidiary study using Sudan grass as an indicator, the effects of pH adjustment using slaked lime and using potassium carbonate as neutralising agents in combination with various rates of application of doube supers were studied. The soil reactions aimed at were pH 6.0, 5.5 and 5.0 and these were compared with the soil without amendment, its pH being 4.6. The double supers comparisons were between the soil without phosphate and the soil with 320, 640 and 1,280 ppm P_2O_5 added as double supers.

Early growth of Sudan grass showed a progressive improvement with increasing pH up to pH 5.5 but not beyond, and even though the soil has an exceedingly low calcium status and a very narrow exchangeable calcium/exchangeable potassium ratio, the improvement was almost as good with potassium carbonate

as neutralising agent, as with slaked lime as neutralising agent. Over a period of seven months with harvesting of the plants as they set seed, the differences between growth in the amended and in the unamended soils evened out, and the main ultimate response was to phosphate application rather than to acidity adjustment.

Analytical Data

The following data obtained during 1954 are of general interest:—

Foodstuffs and Plant Products

Material	Moisture per cent	Ash per cent	Crude Protein per cent	Ether Extract per cent	Crude Fibre per cent
Brewers grains	10·3	—	21·1	5·5	15·2
Castor seed	7·2	—	—	40·0–42·9	—
Chillies	—	—	total	15·6	—
	—	—	volatile	0·3	—
	—	—	non-volatile	15·3	—
Chillies half ripe	—	—	total	10·1–11·1	—
	—	—	volatile	less than 0·1	—
	—	—	non-volatile	10·1–11·1	—
Chillies unripe	—	—	total	2·6	—
	—	—	volatile	0·1	—
	—	—	non-volatile	2·5	—
Copra cake	13·5	—	15·3–23·0	5·4–10·5	—
Cottonseed cake	9·5–11·2	—	23·9–50·4	3·5–11·7	—
Edible canna	10·6	5·5–7·4	2·3–5·9	·4–·5	4·1–4·4
Flamboyant Pod bean meal*	9·4	8·9	7·4	0·5	45·2
Groundnut	8·4	7·3	47·7–49·3	7·1–7·9	3·6
Linseed cake	7·8–11·8	4·3	29·4–38·9	11·0–16·9	8·3
Lucerne meal	12·3	10·5	21·4	1·9	24·7
Lupins Weiko	—	—	38·3	—	—
Sweet Blue	—	—	30·6	—	—
Maize bran	10·2	2·5	8·6	7·6	8·3
Papyrus	4·8	11·0	18·8	2·1	25·1
Pea hay	11·0	—	12·2	—	—
Sim Sim cake	8·3	—	38·9	14·0	—
Silages					
Maize	82·5–85·8	1·6	1·4–2·0	0·4	5·2
Oats	72·7–80·6	2·0–2·5	2·6	0·8	6·1
Oats and Lupin	81·0	2·6	2·9	0·6	6·2
Pea	72·3	—	4·3	—	—
Ritter	76·5	2·5	1·5	0·2	—
Sunflower bran	10·1	10·5	7·6	7·8	25·7
Sunflower heads with seed After threshing	6·4	5·2	9·9	19·3	20·6
	8·9–9·9	9·4–10·4	3·8–5·6	2·7–3·9	16·5–17·0
Sunflower stalks	11·9	9·4	2·4	2·0	47·2

*Free fatty acid content equivalent to 115·2 mgm. KOH per 100 gm. dry feed.

Fertilizers, Manures and Mineral Supplements

Material	Moisture per cent	N per cent	P_2O_5 per cent	K_2O per cent
Precipitated calcium phosphate	33·7	—	29·3	—
Urea	—	46·4 46·8	—	—
Chicken manure	11·9–13·3	1·5–2·6	2·4–4·1	1·7–1·9
Blood meal	6·5	9·1	8·4	0·7
Cottonseed cake	9·1	6·1	4·1	2·1
Bone meal	6·8	3·7	28·4	0·2
Bat Guano	—	2·7	2·3	—

A range of limestones which were examined for their fluorine content in connexion with their suitability for incorporation in mineral supplements was found to contain between 7 and 52 ppm of fluorine. A sample of crude salt examined in the same connexion was found to contain 9 ppm.

Weed Killers

The ultimate recovery of the 1953 crop from the effects of hormone weed killers restored farming confidence in their safety on maize, and in consequence, a fairly large acreage once again was sprayed in 1954. No damage to the 1954 maize crop through the use of these weed killers has been reported.

The prickly pear infestations which were sprayed in 1953 with D.N.O.C. at 20 per cent and at 2 per cent in mineral oil and T.C.A. at 5 per cent in water remained under observation during 1954. Additionally, other infestations were sprayed with the butyl ester of 2, 4, 5-T and with a mixture of the butyl esters of 2, 4-D and 2, 4, 5-T in tractor vapourising oil. The 2, 4, 5-T ester spray contained 100 ml of 40 per cent concentrate in every gallon. The mixed spray was prepared by dissolving in 5 gallons of vapourising oil, 4 pints of commercial brushwood killer containing 26.6 per cent 2, 4-D and 13.3 per cent 2, 4, 5-T. The T.C.A. and the 2, 4, 5-T preparations, though relatively slow acting, caused severe dieback of the infestation and shedding of the fleshy stems, and an unhealthy yellowing of growth. In no case, however, has the single application led to a complete kill, and in the case of the 20 per cent D.N.O.C. treatment, regeneration from surviving tissue was apparent within a year of spraying. The effect of the 2 per cent D.N.O.C. treatment was transitory, the sprayed plants quickly making a full recovery. Quite considerable quantities of spray (and of active ingredient in the spray) were found necessary for covering even relatively small infestations satisfactorily, and if the infestation is large, it is virtually impossible to obtain a complete and satisfactory cover. On this account, direct chemical control of prickly pear using the chemicals tested (and these are the chemicals now commercially available for the purpose) will be an extremely costly operation. The greatest possibilities in the use of chemical control of prickly pear probably lie in the spot control of young regrowth after hand or mechanical clearing of existing infestations. Opportunity for trying control along these lines exists in the projected clearing scheme at Mariakani.

Publications

"Review of Fertiliser Responses in Kenya": E. Bellis. "Transactions of the Fifth International Congress of Soil Science, 1954", Vol. 3, 274–278.

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Continued acknowledgment must be paid to the industry of officers of the Chemical Section and to the assistance given by other officers both in the Agricultural Department and in other departments and of the general public. Without it, the considerable body of work referred to here could not have been undertaken. In particular, I would like to acknowledge the work of the Agricultural Officers and Assistant Agricultural Officers (Experiments), and the field staff of North Nyanza on whose work much of the progress reported in the section on Fertilizers is based. Dr. Whelan contributed the sections on Organic Matter Studies on Soils of the Kenya Highlands, and on Lime-Fertilizer Experiments. Mr. Butters contributed the section on Njoro Pumice Soils and most of the section on Embu Bracken Soils.

E. BELLIS,
Soil Chemist.

ANNUAL REPORT OF THE SENIOR PLANT BREEDER, 1954

I.—Wheat General

The Season

After an exceptionally dry year in 1953, the rains broke early; and a good season was experienced. In the Rift Valley rainfall was in general above the average, but tended to be rather lower than average in areas west of the Rift. Distribution was good, with rain persisting well on towards the end of the year. As a result yields are expected to be above average for all areas of the country.

The monthly totals at Njoro, and the number of days upon which rain fell, are as follows:—

Rainfall

Month	1954	25 years' Average
January	Nil (0)	0·81
February	0·70 (5)	1·13
March	0·24 (4)	2·69
April	9·25 (23)	5·67
May	9·64 (25)	4·26
June	6·17 (21)	3·41
July	6·05 (22)	4·52
August	3·04 (14)	4·88
September	1·94 (9)	2·55
October	3·05 (14)	1·94
November	1·79 (14)	2·49
December	0·66 (7)	1·77
Total ..	42·53 (158)	36·12

The Colony's wheat crop this season amounted to 1,485,500 sacks of 200 lb. compared with 1,329605 sacks reaped in 1953. This represents an increase of some 156,000 sacks (12 per cent) over the 1953 figure. Acreage figures are 290,963 for the present season compared with 289,254 for 1953, an increase of some 1,700 acres (½ per cent). The average yield this season was 5.10 sacks per acre compared with 4.60 last season. The comparison may be summarized as follows:—

1953 (Actual)			1954 (Estimated)		
Acres '000	Sacks '000	Sacks/Acre	Acres '000	Sacks '000	Sacks/Acre
289	1,329	4·60	291	1,485	5·10

Review of Main Varieties

The main varieties grown in Kenya during the season, together with their acreage percentages for the three-year period 1952–1954, are given below:—

Acreages Percentages 1952–1954

Variety	1952 %	1953 %	1954 %
Sabanero	18·1	16·4	13·3
Cross 294	19·2	17·9	12·8
131	9·2	11·2	10·1
1066	13·4	13·1	9·9
360 H	9·3	9·8	7·3
341	1·1	1·5	7·2
Equator	3·9	7·4	6·9
Cross 318	12·1	7·8	6·9
337	2·1	2·8	6·7
R. 64	0·5	2·1	6·2
184	0·5	1·5	4·6
261 R	1·2	1·0	1·2
Regent	0·4	0·3	0·5
Pohls Plateau	1·5	2·1	0·3
Remainder	7·5	5·1	6·1
	100·0	100·0	100·0

The most noticeable difference in the pattern of distribution over the past two seasons has been the decline in acreage percentage sown to Sabanero, 294, 131, 1066, 360, Equator and 318, each of which individually has shown a decrease when compared with 1953. This overall decrease (16.4 per cent) is almost exactly counter-balanced by increases in 341, 337 and R.64 and 184 (16.8 per cent). Sabanero is now the most popular variety, replacing 294 which fell from first to second place this season.

The five premium varieties discussed in the 1953 report, R.64, 261 R, 184, Regent and Reward, have together increased from 5.1 per cent to 12.7 per cent of the total acreage this season; and this is probably the direct result of the premium policy. Milling concerns in Kenya are very perturbed at the gradual and progressive deterioration of wheat quality in the country as a whole, and the suggestion has been put forward that this deterioration may be due to the increase of low-quality varieties such as 1066, 131 and Equator. In point of fact, taking only these three varieties, there has been a drop from 31.7 per cent in 1953 to 26.9 per cent in 1954, and the cause of this deterioration may therefore have to be sought elsewhere. It is more than probable that "wheat-bashing", which still obtains over a considerable area of the country, is really at the root of the trouble. Nevertheless, there is now a distinct and encouraging move towards more balanced farming in the more enlightened areas. This is particularly true of the lower country where suitable grass types for leys are available. It is somewhat difficult in the high country (where Take-all is a serious problem) to find satisfactory alternative crops to wheat and barley, and oats has only a limited market. It may be expected, however, that with the development of suitable grasses for the high altitude areas improvement may also take place in these areas.

Rust and Other Diseases

There has been a serious increase in all diseases attacking wheat.

Black Stem Rust (*Puccinia graminis tritici*) was again widespread and attacks were severe on some farms. In particular, the varieties 294 M, 360 H and 318 AJ were badly attacked and damaged in some cases. It is apparent that these three varieties, as has been forecast over the past two years, have now become very susceptible to the disease and can no longer be regarded as "safe" wheats. The variety 294 M, which has headed the list as the most popular Kenya wheat for a number of past seasons, dropped to second place in 1954, and increasing rust attack provides a further warning for the future. These three varieties may well continue to be useful wheats for a number of years to come, but too much reliance must not be placed upon them in the planting programmes in view of their rust susceptibility.

As was feared last year, the appearance of two new forms of Black Stem Rust has now been established, making the 13th and 14th forms to have been isolated in East Africa. These new forms are discussed separately in the next section of the report.

A field survey carried out last season showed that the main stem rust forms in Kenya were K9, 11 and 12, with 10 and 14 isolated on a smaller number of occasions; in Tanganyika K9, 11 and 14 were the dominant forms. This is substantially the position that obtained last year, except for the arrival of K14. These four are likely to be the dominant forms again during the coming season, and it is unfortunate that most of the varieties being grown at the present time are susceptible to one or more of them.

Brown Rust (*P. triticina*) was not extensive during the year, although it appeared at all altitudes. On the other hand Yellow Rust on leaves and in the ears (*P. glumarum*) was much more prevalent and came to lower altitudes than usual, due to the cool season. The variety 341 was for the first time seriously damaged by attacks of Yellow Ear Rust and is likely to lose popularity on that account. This widespread attack on 341 strongly supports the earlier view that different forms of this rust occur, but unfortunately this is not a problem which we are as yet able to investigate in detail.

Glume Blotch (*Septoria nodorum*) and Black Chaff (*Xanthomonas translucens*) were prevalent, as is usual in a wetter season, and must have reduced yields to some extent.

Take-all (*Ophiobolus graminis*) showed a further considerable increase in 1954 and must now be considered as having reached very serious proportions over most of the higher altitude wheat lands. This situation can only be remedied by a radical change of policy, as was explained in the 1953 report. Wheat monoculture is the root cause of the prevalance of this disease and it will continue to do considerable damage until more balanced farming methods can be adopted. The difficulty, as explained earlier, is to find suitable alternative crops to wheat or barley in these areas.

Reference was made in the 1953 report to the new seed-borne disease of wheat caused by the fungus *Pyrenophora tritici-repentis*. Whilst earlier work suggested that the disease could be controlled by seed dressing, more recent evidence shows that there can be a carry-over in infected soil. In such cases seed dressing will be of no avail once the fungus has become established in the land. Although little is yet known concerning the persistence of the disease in

the soil, it is likely that adequate crop rotation will be necessary for its control. The best form of control is prevention and this can best be assured by the use of seed from clean crops suitably dressed with an organo-mercurial compound. The cost is small and this treatment of seed is advised as a measure against seed-borne diseases in general.

Black Stem Rust—Confirmation of Two New Forms

In last season's report it was stated that there was the probability that two new physiologic forms of Black Stem Rust had arisen. This has now, unfortunately, been confirmed; these two new forms make the 13th and 14th stem rust forms to be isolated in East Africa. Both forms were first isolated in 1953—form K13 from the variety 360 H in the breeding cages at Njoro and K14 from the newly released premium wheat R 64 on the Kinangop. The field attack in 1953 was only mild and sporadic and no damage was suffered by the crop in question. During the past season K13 appeared only once, but K14 was isolated on a number of occasions both in Kenya and in the Northern Province of Tanganyika. In Kenya a number of new and promising wheats in the course of multiplication for possible release were attacked, and this attack by K14 may well mean that they may now have to be discarded. In Tanganyika both R 64 and a number of new wheats under test in the Northern Province were similarly attacked. In the case of R 64 it is interesting to note that the field attack was only mild, and it may be that the variety shows some resistance to this rust form. Be that as it may, it is unfortunate that this rust has attacked a number of new varieties which were shortly due for release, and this must occasion a serious set-back to the breeding programme. It has not yet been possible to test the established wheat varieties for seedling resistance to the new forms K13 and K14. The reactions of these two forms on the differential series are given in the Pathologist's section of this report.

II.—Wheat Breeding

As has been stated in earlier reports, this work is centred at Njoro and Molo, and further testing and multiplication is undertaken at Eldoret, Rongai, Ol' Joro Orok, Kinangop and at Egerton College (Njoro). In the lower areas breeding is mainly for resistance to Black Stem Rust and also Brown Rust, but at the higher altitudes resistance to Yellow Leaf and Ear Rust becomes more important.

In view of the large amount of material now carried, it is not possible to give such detail as was done in the past. As a result, reports on introductions of all cereals will be issued from time to time in the form of special bulletins for mailing to those who have sent breeding material to us. Only the special points of interest can now be covered in the Annual Report.

Cage Material and New Accessions

(a) Njoro

Again no new crosses were made, and the work was devoted to further selection in the wealth of material derived from earlier crossings. In summary, there were 360 F_3s from 30 straight crosses and 64 F_2s from 22 backcrosses. There were an additional 71 F_3 and 65 F_2 bulk selections in the field, representing 89 crosses in all. The five crosses referred to in last year's report have advanced a generation further and first bulks have now been made for field work in 1955. (Crosses 372, 374, 337, 381, 398.)

A total of 100 introduced wheats were grown in 1954. Seven Egyptian wheats were completely killed by Yellow Leaf Rust. The South African varieties Hopeful and Impala showed promise and are to be grown again for observation in 1955. Of seven wheats from Perth, Australia, only Sabre, M 107 and Reldep have been kept for further study. A collection of breeding material from the University of Idaho, U.S.A., proved very disappointing and was very heavily damaged by Ear Blotch. Only two out of 16 of the varieties have been kept.

A large collection of 39 varieties from the Rockefeller Foundation, Mexico, proved much more useful and 19 have been kept for further use. The majority of these strains are of Yaqui, Kentana or similar parentage coupled with Kenya ancestry and seem very promising in appearance, mainly because of their short straw.

A collection of 17 European spring and winter wheats was received from the National Institute of Agricultural Botany, Cambridge, but proved once again that such wheats cannot be used in Kenya. All the winter varieties remained vegetative, and although the spring or alternative varieties headed they were very badly damaged by Stem Rust. It had been hoped that some of these varieties would show resistance to Yellow Rust, and accordingly the collection was also sown at Molo, the high-altitude sub-station.

In addtion to new material, 52 varieties that had been harvested from the International Rust Nursery of 1953 were grown in 1954 for further observation. These proved promising in some cases and 11 have been selected for small multiplication plots in 1955. There will also be some single plant cultures.

Those accessions kept for further use will be given seedling tests to the later stem rust forms to assess their worth for direct use or as parents in further breeding.

(*b*) *Molo*

Selected bulks from two Equator crosses (384 and 385) were grown in the field for the first season last year, and single plant cultures were included in the cage in case field plots still showed some further segregation. There were 195 F_5 cultures of these two crosses in the cage and 68 field plots. Due to heavy infections of Yellow Ear Rust, and marked differences in susceptibility between cultures, it has been possible to make a fairly rigorous selection on that basis and to reduce the material accordingly.

To provide material for future work a further 19 crosses at the F_2 stage were brought to Molo this year, involving 56 cultures in all. In addition, certain accessions were also grown there, particularly the N.I.A.B. wheat collection referred to above. All these latter varieties eventually came into head, though the winter varieties were slow to do so. They all became attacked by rust, *P. graminis, P. glumarum* and *P. triticina.* Those least affected by Stem Rust were Fylgia and Bersee. The majority showed some resistance to Yellow Leaf Rust and Nord Desprez was particularly damaged by this rust. Brown Leaf Rust became extensive on all varieties.

(*c*) *Co-operative Rust Nurseries*

As was reported last year, we have joined co-operative work in the testing of large numbers of varieties in rust nurseries. The International Nursery received from America contained 532 varieties this year and these were sown in the cage with an artificial infection of Stem Rust on surrounding material. A full record has been sent to America.

Similarly the Near East Co-operative Wheat Rust Nursery—1953/54 was grown. This contained 272 varieties and was sent out by the F.A.O., Rome. This nursery gave less material of value, and in particular the agronomic characters of the wheats seemed less satisfactory. A full report has been sent to the F.A.O., Rome. (The Near East Barley Nursery will be referred to in the barley section of this report.)

A total of 79 varieties from these nurseries has been kept for further use as showing signs of value to the Kenya wheat work.

Wheats Under Initial Multiplication

Space will not allow of a full report on all varieties, and only varieties of special merit will be specifically mentioned.

(*a*) *Njoro*

In addition to the bulk early generations of new crosses, mentioned under the section above on work in the cage, only material from cross 367 was grown on the Plant Breeding Station. The 356, 358 and 360 F.8.X series referred to last year had all moved on to field multiplication with farmers or other Government stations. There were 14 selections of the cross 367 grown at Njoro, but very high infections with Yellow Leaf Rust damaged most of them. However, they have good seedling resistance to the later forms of Stem Rust (K9–14) and may be useful in the medium to low-altitude range, where Yellow Rust is not normally so virulent as it was this year.

A total of 57 introduced varieties were grown and the majority of them have now shown too little promise to be worth continuing. This is usually the case in Kenya and few importations are of direct use. Those which have proved the exception, and will be multiplied further, included the following: H 305–10 from Wisconsin, two Florence x Aurore derivatives from Algeria, three *Triticium* x *Secale* derivatives from South Africa and Spica and KIS from Australia. In general the level of Yellow Leaf and Ear Rust on these introduced varieties was too high, and rigorous selection has been made on that account. After several years of observation, the majority of the South African varieties received in 1951 have proved too low yielding and possess insufficient rust resistance. Similiarly, the group of wheats from Poona, India, have been discarded for the same reasons, and for weak straw. Certain introduced varieties received in 1950 or earlier have reached field stage multiplication and will be referred to later.

(*b*) *Rongai*

There were 11 wheats under small-scale multiplication this year, mostly varieties from India which it was thought might be better at that lower altitude. A large-scale flooding and washaway four days after the sowing did much damage, but small stocks of each variety have been salvaged for further trial. Nos. 4, 5 and 113 looked the most hopeful.

Two selections revived from the cross 339 (192.Q.2.A (L) x Austr. 37) did very well; they are short-strawed, beardless types with white grain. They were badly defoliated by Yellow Leaf Rust this year, but this would not usually happen at such low altitudes.

(c) *Eldoret*

There were six selections from the 360 F.8.X series under multiplication. All proved very similar—short-strawed and attractive from the farmers' viewpoint, but not good on baking quality. 359 AA.8.B.1.A was again multiplied and reached 8½ bags of seed. All the other 359 selections have now been withdrawn because of Stem Rust susceptibility, but it is hoped that this one can be continued because of its excellent baking quality. This variety was first in the Njoro trial this year, so may not be so low yielding as was thought in earlier years.

(d) *Molo*

As already mentioned, the first field plots of selections from crosses 384 and 385 were grown again this year. There were 68 such selections in the field, but this reduced to 54 at harvest, mainly on Yellow Ear Rust susceptibility, and others will be discarded on grain quality in the laboratory. The two best 362 selections, and three 1066 selections, have now gone out to farms for multiplication, but a further three 362s were grown at Molo. Of these, only one showed sufficient rust resistance this year to merit further multiplication—selection 362.P.1.B.3.

(e) *Ol' Joro Orok*

Only the durum variety, Capella, was multiplied this year, but trials were also undertaken as noted later.

Variety Trials

Yield trials were again carried out at Njoro, Eldoret, Ol' Joro Orok and the Kinangop. To give some idea of the quantity of material under trial and in field observation plots, including barley and oats, the following table summarizes the 1954 position:—

Table I

Station	Varieties in Trials			Observation Plots		
	Wheat	Barley	Oats	Wheat	Barley	Oats
Njoro ..	31	25	—	242	16	1
Eldoret ..	25	21	21	—	9	11
Ol'Joro Orok	15	15	15	—	16	13
Kinangop ..	15	15	15	—	—	6
Kitale ..	—	—	12	—	29	9
Rongai ..	—	—	—	11	—	—
Molo ..	—	—	—	86	38	56
Totals ..	86	76	63	339	108	96

In the following tables of results of individual wheat variety trials, the yields are expressed in bags of 200 lb. net per acre:—

(*a*) *Wheat Variety Trial—Njoro*

(Six replications of 31 varieties in incomplete randomized blocks.)

TABLE II

Variety	Yield (*bags* 200 *lb./acre*)	Bushel Weight *lb.*	Position 1954	Position 1953
359 AA.8.B.1.A	8·36	64¾	1	—
Granadero Klein	7·57	60	2	3
Mida Cadet	7·23	60	3	16
358 P.7.A	7·12	62¾	4	30
358 AA.5.B	6·46	62½	5	—
358 P.6.A	6·32	62	6	—
358 P.7.B	6·23	62	7	—
Klein Orgullo	5·84	61	8	—
356 C.3.C	5·66	58¼	9	—
360 H*	5·60	62	10	5
356 A.4.D	5·58	58¼	11	19
358 B.3.C	5·43	58	12	23
358 O.1.A	5·30	58	13	—
358 R.7.E	5·20	61	14	—
356 C.3.E	5·19	59	15	—
358 B.3.E	5·00	59¼	16	22
358 P.7.C	4·99	61½	17	29
RL 2183/C	4·73	56	18	—
356 C.9.D	4·64	55¾	19	—
356 A.12.C	4·63	57	20	15
358 B.3.H	4·33	60	21	—
RL 2183/E	4·16	54¼	22	—
358 AC.4.A	4·00	56½	23	17
356 A.4.C	3·94	55¼	24	12
RL 2183/D	3·94	55		—
358 AI.2.A	3·91	60½	26	—
RL 2150/A	3·86	57¼	27	—
358 B.3.G	3·56	59	28	14
356 A.2.A	3·48	56	29	1
358 R.3.C	3·45	58¾	30	24
356 C.4.C	3·33	54½	31	—
MEAN	5·12			(7·53)†
Significant differences—				
P.05	1·29			
P.01	1·72			

*Established variety.

†Mean yield in 1953.

The superior performance of 359 AA was not expected, since this variety had earlier been discarded for poor yield and was only revived on account of its excellent baking quality. Granadero Klein, in spite of its good yield, has had to be discarded on account of Yellow Ear Rust susceptibility. In general, the

358 selections (184.P.2.A.1.E x 294.B.2.A.3) have done better than the 356s (184.P.2.A.1.F x 192.Q.2.A (L)), and a number of them were grown at Egerton College this year ready for further multiplication by farmers. This tendency is in contrast to that of last season, when the 356 series yielded better than the 358; however, the seasons were very different. In particular, it is gratifying to note that the 358.P group of selections, noted last season for their better grain quality, head the list of 358s this year. On the other hand, 356.A.2.A, first last year, has dropped to 29th this season.

(*b*) *Wheat Variety Trial—Eldoret*

(Six replications of 25 varieties, in incomplete randomized blocks.)

TABLE III

Variety	Yield (*bags* 200 *lb./acre*)	POSITION	
		1954	1953
360 F.8.X.5.B	16·14	1	1
360 F.8.D.3..	15·84	2	5
360 F.8.X.6.A	14·48	3	3
360 F.8.X.3.B	14·23	4	2
354 P.3.B.2.B	13·32	5	7
Mida Cadet	13·05	6	—
354 P.3.B.5.B	12·96	7	4
Granadero Klein	12·14	8	—
RL 2150/B	12·10	9	—
358 AC.4.A..	11·89	10	6
356 A.2.A	11·28	11	—
RL 2183/D	10·37	12	—
RL 2183/C	9·97	13	—
359 AV. 1.B.1.A	9·85	14	10
359 AA.8.B.3.B	9·19	15	—
356 A.12.C	9·10	16	—
356 A.4.D	8·74	17	—
358 B.3.G	8·69	18	—
Regent Type (M–B)	8·44	19	—
Hope Timstein	8·29	20	16
Regent Type (Boy)	7·83	21	12
360 E.13.C.4.G	7·56	22	—
360 H*	7·40	23	20
359 AV.1.C.2.C	6·79	24	18
W. 1	3·63	25	—
Mean	10·53		(4·72)†
Significant differences—			
P.05	2·27		
P.01	3·04		

*Established variety. †Mean yield in 1953, low due to drought.

As was the case last year, the 360 selections have headed the list, followed by the 354s. Of the 356s, the A.2.A selection seems to yield rather better than the A.12.C. This was also the case at Njoro in 1953, though not in 1954. Of

the 358 selections, AC.4.A was the better-yielding variety last year and has repeated this in 1954; though at Njoro it has not done particularly well in either year compared to other selections. The poor performance of the established variety 360H is notable, and also the imported variety W.1 from South Africa.

(c) Wheat Variety Trials—Ol' Joro Orok and Kinangop

(Six replication of 15 varieties, in incomplete randomized blocks.)

TABLE IV

Variety	Ol' Joro Orok			Kinangop		
	Yield (*bags/acre*)	Position		Yield (*bags/acre*)	Position	
		1954	1953		1954	1953
362 B.1.A.2	13·10	1	9	5·38	12	6
B.1.A.1	12·68	2	6	6·44	6	4
B.1.A.3	9·84	3	15	6·73	5	5
B.1.E.4	9·76	4	13	6·04	7	2
P.1.B.3	9·61	5	—	3·94	15	—
B.1.A.4	9·44	6	12	7·31	3	1
B.1.I.1	7·86	7	—	4·44	13	—
361 J.1.B.3.D	7·81	8	—	4·09	14	—
362 A.1.D.1	7·67	9	11	7·47	2	3
A.1.J.1	7·28	10	—	5·83	8	—
Capella	7·09	11	3	7·92	1	6
350 AD.9.C.2	6·78	12	5	7·24	4	15
R. 64*	6·33	13	2	5·69	10	10
362 B.1.D.3.D	6·04	14	—	5·54	11	—
350 AJ.3.C.1	5·60	15	4	5·83	8	11
Mean	8·46	(5·18)†		5·99	(3·53)†	
Significant differences—						
P.05	1·47			1·92		
P.01	1·96			2·55		

*Established variety. †Mean yield in 1953.

At Ol' Joro Orok the order of varieties has shown a clear reversal between two years, due presumably to the great difference between the seasons. The superiority of the 362Bs is worthy of note and in this connexion one selection, B.1.E.4, is already under field scale multiplication. On the Kinangop there is, perhaps, more agreement between the seasons. Here again the 362Bs have mostly done well, and it clear that Capella, 362 A.1.D.1, B.1.A.3, B.1.A.4 and B.1.E.4 are likely to be useful varieties for the area.

Wheats Under Field Multiplication

The quantity of material under field scale multiplication on farms was far greater than ever before. The following table, which also covers barley and oats, gives some idea of the amounts involved. All such multiplication work

is organized and controlled from Njoro and represents a considerable proportion of our efforts:—

TABLE V

Cereal	Varieties	Plots	Acres
Wheat	52	76	1,463
Barley	19	25	138
Oats	14	17	60
TOTALS.. ..	85	118	1,661

The following notes summarize the main points of interest regarding wheats under field scale multiplication, for space will not allow discussion of all varieties concerned.

As mentioned earlier the 359 series of wheats, which had reached field multiplication, was withdrawn at the end of the 1954 season because of their susceptibility to Stem Rust, particularly the new form K14. The variety 354 P.3.B.2.B has done well in a number of areas and in the Eldoret trials and will be released for the 1955 season. Both 356 selections, referred to last year, were successful on a field scale (though disappointing in the Njoro trial) and should be suitable for release when seed supplies are sufficient. The variety 261.E, a sister strain to the established 261.R, which has yielded well in the Nakuru/Solai area, will be released for 1955. At Egerton College, Njoro, eight 358 selections were multiplied and these show considerable promise, as was discussed in connexion with the Njoro trial. In particular, 358 R.7.E, with a yield close to the mean for the trial, has been shown in seedling tests to be resistant to all the later forms of Stem Rust (K9–14), and should be especially valuable. Certain 360 selections have been further multiplied and the 360 F.8.X series at both Eldoret and Rongai has shown excellent field characteristics. Mida x Cadet, introduced from Ottawa in 1950, has done well at Njoro in this wetter year, after a poor performance in last year's drought. Hope x Timstein, also from Canada, was disappointing at Rongai both for field characters and grain.

Of the higher altitude wheats, 362 B.1.E.4 and 362 A.1.D.1 have both done well, especially the former. Varieties for these areas are very much needed and these 362 selections should prove helpful, though their degree of susceptibility to Stem Rust may cause some trouble.

RELEASE OF NEW WHEATS

The following wheat was released during 1954:—

351.AS.1.B.2.—This wheat is from the cross 117.A x Regent 975.6, made at Njoro in 1941. It was released in time for the 1954 sowings. It is a beardless, white-chaffed, red-grained variety of mid-season maturity, fair straw strength and moderate baking quality. It takes from five to five and a half months at Njoro. It is resistant to forms K1–12 of Black Stem Rust in seedling tests, but has been attacked in the field by forms K9 and 12, particularly the latter. It shows

resistance to Yellow Ear Rust up to 8,500 ft. in Kenya and has been recommended for areas from 7,000–8,500 ft. 351 has yielded moderately well but, because of its low tillering rate, sowing at somewhat higher than the usual rate has been recommended.

In addition, the varieties 261.E, 354 P.3.B.2.B and 356 A.12.C are to be released in time for the 1955 season.

III.—Barley

As noted in last year's report, a barley-breeding programme is now under way at Njoro. This is in addition to the continued testing of imported varieties both at Njoro and at Departmental stations at Kitale, Eldoret, Ol' Joro Orok, Kinangop and Molo.

This year barley crops over a wide area, but particularly in the Solai, Nakuru, Njoro and Rongai districts, were very badly damaged by the acivities of Bulb Fly, *Hylemyia arambourgi*. The fly was first found in the Solai area in 1953, but a mass invasion of a wider area this year did great damage to stands of barley. The larvae eat out the centres of the tillers. The effect on all barley grown at Njoro was serious in spite of spraying with Agrocide and, later, a D.D.T. emulsion. It was notable that there were strong varietal differences in the capacity to form fresh tillers and to get away from the attack. However, a suitable economic form of control must be evolved if barley is to be grown satisfactorily in these areas in the future.

Cage Material and New Accessions

The F_1s of the seven crosses made last year were sown during the dry season early in 1954 and the F_2 generation was then sown rather late in the normal rainy season, in August. The F_3s will be sown in the usual season in 1955. The continued success of Scandinavian barleys in Kenya gives hope that these crosses to the established Research and Prior may prove valuable.

Custer, from Utah, U.S.A., was the only new barley variety received for trial in 1954. It proved weak in the straw and not attractive, but it will be given a further trial in 1955.

As noted earlier, the Near East Co-operative Barley Nursery, 1953/54, was received from the F.A.O., Rome. There were 62 varieties in the nursery, upon which a full report has been made, but in general they were disappointing and only five have been kept for further study. Many of the varieties developed more Stem Rust than is normally found on barley at Njoro.

Barleys Under Initial Multiplication

(*a*) *Njoro*

All varieties suffered badly from fly damage and little may be said of them except that of 16 varieties those that seemed the most hopeful were Goudgerste, Goud and Proctor. There are now some four bags of this new British variety ready for multiplication in 1955. The varieties Adliker 9 and Saxonia were particularly badly damaged by the fly and failed to make new growth.

(*b*) *Molo*

It was fortunate that a large proportion of the barley multiplication was taken to Molo this year. There were 38 varieties there, of which the majority were Scandinavian types or Spratt x Archer and similar crosses, These had been received from Eire in 1951. Most of the six-row types were disappointing, but Idaho Winter Club was very attractive. It was slow to ear, having a winter

habit, but it was short in the straw and yielded well. A slow barley of this type would be very acceptable to some farmers in the high country since it keeps the ground covered for a longer period; it was seven months in this case compared with about five and a half months for all the other barleys.

Variety Trials and Observation Plots

In addition to the trial at Njoro, there were trials at Kitale, Eldoret, Ol' Joro Orok and the Kinangop, and also observation plots at these stations. In the following tables of results all yields are given in bags of 180 lb. net per acre.

(*a*) *Barley Variety Trial—Njoro*

(Six replications of 16 varieties, in incomplete randomized blocks.)

Table VI

Variety	Yield (*bags* 180 *lb./acre*)	Position	
		1954	1953
No. 5	9·11	1	3
Kenia	9·03	2	2
Rigel	8·68	3	—
Research*	8·61	4	8
Proctor	8·46	5	—
Carlsberg	8·17	6	6
Binder	8·17		
Goud	8·07	8	—
Heimdal	7·98	9	1
Bonus	7·91	10	—
Goudgerste	7·72	11	—
Adliker 9	7·53	12	—
Balder	7·06	13	5
Mansholt's 2 row	6·72	14	—
Prior*	6·64	15	15
Saxonia	4·32	16	—
Mean	7·76		(9·14)†
Significant differences—			
P.05	1·62		
P.01	2·16		

*Established varieties. †Mean yield in 1953.

It will be seen that the significant differences are rather too large to do more than set the very lowest yielders apart from the rest. This must be attributed to fly damage. Compared with 1953, the varieties Heimdal and Balder have dropped in position, but otherwise there is good agreement. The varieties No. 5, Proctor and Carlsberg have all been under multiplication this year, and Kenia was released for the 1954 season. It will be recalled that in 1953 the trial had to be irrigated to prevent total loss, but this year natural rainfall was fully adequate. Nevertheless yields have fallen from an average of 9.14 bags in 1953 to only 7.76 in 1954, and the best performances from 13.46 to 9.11 bags respectively.

(*b*) *Barley Observation Plots—Kitale*

The large range of American varieties was reduced to only 13 this year and a number of Scandinavian and other types was tried out. Once again weed growth nearly smothered many varieties. In the large plots Trabout, Ymer, Prior and Ray did best, in the smaller plots No. 5, Herta and Research.

(*c*) *Barley Variety Trial—Eldoret*

(Six replications of 21 varieties, in randomized incomplete blocks.)

TABLE VII

Variety	Yield (*bags* 180 *lb./acre*)	Position
Velvon	12·63	1
Binder	11·55	2
No. 5	11·07	3
Tregal	10·90	4
Trebi	10·90	
Prior*	10·46	6
Kenia	10·37	7
Heimdal	9·83	8
Carlsberg	9·74	9
Hannchen	9·47	10
Velvet	9·35	11
Plush	8·89	12
Ymer	8·81	13
Sanalta	8·62	14
Herta	8·48	15
Research*	8·38	16
Balder	7·58	17
Wisconsin	7·56	18
Chevron	6·87	19
Ray	5·80	20
Peatland	5·55	21
Mean	9·21	
Significant differences—		
P.05	2·14	
P.01	2·86	

*Established varieties.

Velvon did well at Njoro and Ol' Joro Orok in 1953 coming first in both trials. It has also done well in the past in Eldoret. It was multiplied at Egerton College, Njoro, and at Kitale this year and should be a useful six-row feed barley for quite a wide range of conditions. Again No. 5 has done rather better than the other Scandinavian types (with the exception of Binder), but Kenia, Heimdal and Carlsberg are not significantly lower in yield. It is interesting to compare this with the Njoro trial and to note the reversal of the positions of the two established varieties Research and Prior. In this case Prior is significantly higher than Research, whereas at Njoro the opposite is true ($P=0.05$ in both cases).

In addition to the trial there were nine other varieties in observation plots, of which Elsess yielded rather higher than the majority, but there was no great difference between most of them. All were six-row types.

(d) Barley Variety Trials—Ol' Joro Orok and Kinangop

(Six replications of 15 varieties, in randomized blocks.)

TABLE VIII

Variety	Ol' Joro Orok			Kinangop	
	Yield (*bags* 180 *lb./acre*)	Position		Yield (*bags* 180 *lb./acre*)	Position
		1954	1953		1954
Trebi	21·15	1	3	18·50	1
Heimdal	15·49	2	—	—	—
Velvon	15·44	3	1	16·62	3
No. 5	15·39	4	—	—	—
Herta	15·34	5	7	15·36	5
Balder	14·48	6	—	—	—
Kenia	14·36	7	6	16·90	2
Ray	14·27	8	10	12·00	8
Ymer	13·77	9	4	15·65	4
Carlsberg	13·46	10	—	—	—
Prior (Hopkins)	13·00	11	2	13·84	6
Prior (Standard)*	12·67	12	5	12·28	7
Standwell	12·15	13	—	—	—
Tregal	11·85	14	8	6·18	11
Research*	11·12	15	9	10·29	9
Mean	14·26	(13·43)†		13·41	
Significant differences—					
P.05	2·26			1·86	
P.01	3·01			2·47	

*Established varieties. †Mean yield in 1953.

The yields at Ol' Joro Orok were surprisingly good, considering that the trial was eaten down by locusts at an early stage of growth in July. Trebi has given an outstanding yield this year. Last year it was third in a trial of 11 varieties, but was noted as having grown rather poorly in the multiplication plots. It has been multiplied both in the Ol' Joro Orok area and at Kitale this year and looks to be a valuable variety. Velvon has done well again, and so have the Scandinavian types Heimdal, No. 5 and Herta. The latter variety, now released, seems best suited to moister growing conditions; and it is likely that Heimdal, another very aggressive variety, also benefits from such conditions. Both No. 5 and Heimdal have been multiplied at Egerton College, Njoro, this year. It is notable that Research always seems to do poorly at Ol' Joro Orok.

On the Kinangop, where it was intended that the same varieties should be in trial, difficulties prevented this and the full comparison is not possible. There is broad agreement over the order of merit, but with Kenia and Ymer showing to greater advantage on the Kinangop than at Ol' Joro Orok.

There were six varieties in observation plots on the Kinangop, all of them six-row feed types. Vaughn yielded at the rate of 26 bags per acre and was far ahead of the next best, which was Cape, yielding at the rate of 19 bags

per acre. In observation plots at Ol' Joro Orok the varieties concerned were mostly Spratt Archer types, similar to those grown under initial multiplication at Molo, but with some Scandinavian types also. Proctor and Maja, yielding at the rate of 16 bags per acre, gave the highest yields. The best Spratt Archer type yielded 14 bags per acre, which was better than that achieved by the remainder of the Scandinavian types. (These yields were from areas of 1/20th–1/50th acre only.)

Barleys Under Field Multiplication

As noted earlier, damage by the fly *Hylemyia* set back the multiplication work in the Njoro area. In spite of this yields were surprisingly good, and at Egerton College one and a half acres of Carlsberg yielded at the rate of over 14 bags to the acre. This is the one Scandinavian variety which, at the moment, the breweries consider may be acceptable as a malting variety, though others do produce a malting sample on occasions. Carlsberg and No. 5 appeared the better of the new varieties under multiplication, but Kenia (now released) also did very well again, yielding 14½ bags per acre over 14 acres. The other varieties were Velvon, Heimdal and Balder.

At Kitale the four barleys Velvon, Trebi, Ray and Colville were multiplied, the two former having done well over a range of areas, as discussed in the notes on the trials. Czech and Blue Barley both suffered fly damage at Rongai and were not very successful. Details of yields on many farms have not yet been received, but the more outstanding crops were Trebi and Standwell, the latter received from Britain a few years back.

Release of New Barleys

The varieties Kenia and Herta were released for the 1954 sowings. These Scandinavian varieties (from Denmark and Sweden respectively) are short, stiff-strawed, high-yielding, two-row types which have done well over the past few years in a number of areas in Kenya. Herta has also done well in the West Kilimanjaro area of the Northern Province of Tanganyika. Kenia has been recommended for all areas of Kenya from 6,500–8,500 ft., having a growing season of five to six months. Herta is of the same maturity as Kenia, but because of drought susceptibility has been recommended for the higher and moister areas over 7,000 ft. These varieties are not generally considered suitable for malting, though on occasion they can produce a malting sample. Herta particularly is not favoured by maltsters.

IV.—Oats

It has not yet proved possible to undertake oat breeding work and efforts are devoted to the testing of introduced varieties, some of which show considerable promise. As stated last year, the bulk of the work has been moved to Molo to avoid the severe attacks of Stem Rust and Crown Rust—(*Puccinia graminis* and *P. coronata*)—which occur each year at Njoro.

New Accessions

Few new varieties were received for trial this year. Delair from Mississippi, U.S.A., looked quite good at both Njoro and Molo. A group of four varieties from Wisconsin, U.S.A., all proved very lush at Njoro and were badly attacked by Stem Rust. X 436-2 and X 532-1 showed a semi-resistant reaction to Crown Rust. Rodney from Canada was badly attacked by both rusts.

Oats Under Initial Multiplication

A total of 56 oat varieties was grown at Molo, a number of them proving very attractive. Of these 34 have been kept for further study. Amongst the better varieties were Fultex, Mustang, Hajira-Joanette, Mindo x (H-J x Landhafer), Andrew, Mohawk, Mulga, 3003.F, Roxton, RL 127, Overland, 4189 x Overland and certain Anthony-Bond x Boone derivatives. Fultex, a grain type, was short strawed and high yielding. It was the most outstanding oat of the series, with Roxton as the most vigorous hay or silage type. At other stations various oats were tried on a small scale and these are referred to in the following section.

Oat Variety Trials and Observation Plots

Oat trials were grown at Eldoret, Kitale, Ol' Joro Orok and the Kinangop, and there were also observation plots at these stations. In the tables of results which follow all yields are given in bags of 150 lb. net per acre.

(a) Oat Variety Trial—Eldoret

(Six replications of 21 varieties, in incomplete randomized blocks.)

Table IX

Variety	Yield (*bags* 150 *lb./acre*)	Position	
		1954	1953
3003 F.	13·55	1	16
Mulga	9·88	2	—
RL 1734	9·03	3	13
RL 1692	8·85	4	14
Clinton	8·58	5	18
RL 1674	8·24	6	15
RL 1694	7·87	7	10
Vichland	7·73	8	12
R1 1681	6·93	9	11
Tama	6·79	10	8
Control	6·47	11	6
RL 1710	6·35	12	19
Vikota	6·19	13	9
Boone	6·10	14	4
Lampton*	5·70	15	1
Cedar	5·63	16	7
Achilles	5·25	17	3
Mindo	5·14	18	5
Ajax	4·98	19	2
Fultex	3·24	20	17
Grey Algerian*	3·15	21	21
Mean	7·12		(13·36)†
Significant differences—			
P.05	3·18		
P.01	4·22		

*Established varieties. †Mean yield in 1953.

The trial was very badly damaged by lodging and breaking, as is reflected in the mean yield of 7.12 bags per acre compared with 13.36 last year. There is a clear reversal of the order of yield, excepting the last two varieties. If the actual yields of 3003.F in the two years (13.55 and 12.43) are compared the difference is slight. The better varieties of last year have yielded poorly this year, but the lower varieties of last year have held their yield more or less constant and have therefore improved their position in the order of merit. 3003.F has shown promise at Njoro and Ol' Joro Orok and has been multiplied at both places, though with disappointing results at Njoro (Egerton College) due to severe rusting. RL 1734 has yielded rather less this year in spite of its improved numerical position (9.03 bags compared to 13.82) and is under multiplication at Kitale, Eldoret and Ol' Joro Orok. In spite of doing rather poorly in this year's trial, Vikota did extremely well under field multiplication on a farm only few miles away.

In observation plots Belar, Bonda and Valor were well ahead of the other seven varieties in yield, though lodging spoilt the plots considerably.

(*b*) *Oat Variety Trial—Kitale*

(Six replications of 12 varieties, in randomized blocks.)

TABLE X

Variety	Yield (*bags* 150 *lb./acre*	Position
Vichland	4·79	1
Lampton*	4·79	
Vikota	4·34	3
RL 1734	4·09	4
Achilles	4·02	5
Boone	3·77	6
Cedar	3·32	7
Mindo	2·75	8
3003.F	2·60	9
387	1·57	10
389	1·45	11
416	1·39	12
Mean	3·24	
Significant differences—		
P.05	0·81	
P.01	1·08	

*Established variety.

This is the first year in which an oat trial has been grown at Kitale. Yields were poor, but the significant differences are reasonably small and effective. The varieties Vichland, Vikota and Cedar were multiplied at Kitale during the season and RL 1734 was out with a farmer in that area. The choice of these varieties, judged on this year's trial, has thus been shown to have been a sound one.

In the observation plots no variety exceeded Lampton in yield, though Tama was the nearest; both these varieties were later than the others by two weeks. Best growth, from a silage or hay viewpoint, was produced by Landhafer x (Mindo x Hajira-Joanette). This was also noted as a good variety last year at Eldoret, Ol' Joro Orok and the Kinangop, and has shown relative freedom from rust in both years.

(*c*) *Oat Variety Trials—Ol' Joro Orok and Kinangop*

(Six replications of 13 varieties, in randomized blocks, at both stations.)

The trial at Ol' Joro Orok had to be abandoned after damage by locusts and, later, by bad weather conditions.

TABLE XI

Variety	Yield (*bags* 150 *lb./acre*)	Position	
		1954	1953
Vicland	21·33	1	—
Boone	19·44	2	5
Vichland	18·60	3	1
Tama	18·27	4	4
Vikota	18·10	5	9
Control	17·52	6	3
Cedar	16·68 ‡	7	—
RL 1734	14·84	8	8
RL 1674	14·49	9	7
Ajax	19·98	10	11
Achilles	8·76	11	10
Lampton*	7·94	12	12
Grey Algerian*	3·14	13	—
Mean	14·79		(5·62)†
Significant differences—			
P.05	2·11		
P.01	2·80		

*Established varieties. †Mean yield in 1953.

‡Due to the use of a missing plot technique in the analysis of results, for all comparisons involving Cedar the significant differences are 2.45 and 3.26 bags per acre respectively.

The very wide range of these yields is notable, the low yields of Lampton, Achilles and Grey Algerian being directly linked with Stem Rust attack. Vichland, Vikota, Cedar and RL 1734 were all multiplied during the year and it looks as if they may be expected to do well in the Kinangop area. The broad agreement for the two years is clear, in spite of the difference in the mean yield; the main exception is the improvement in position achieved by Vikota.

In observation plots on the Kinangop the most successful variety was Mindo, since all the other five varieties were more heavily attacked by Stem Rust. Last year it was Landhafer (Mindo x Hajira-Joanette) which remained free from rust, and Mindo was as rusted as the others. This gives evidence of the presence of differing forms of this rust in Kenya.

Oats Under Field Multiplication

The variety Vikota was multiplied on a farm just outside Eldoret and yielded at the rate of 19 bags per acre off 14 acres. This is a grain type of oat, but early tests show that it is not promising as a variety for porridge making. Boone, multiplied at a rather higher altitude, did less well but will still be continued. RL 1734 was multiplied in the Kitale area and continues to show promise as a forage variety; there were also plots on the Eldoret and Ol' Joro Orok stations. The variety 3003.F was grown at Ol' Joro Orok and at Egerton College, Njoro, and has continued to do well in trial and observation plots. The multiplication at Egerton College was not successful, due to damage by Crown Rust, but that at Ol' Joro Orok was more satisfactory.

Release of New Oats

No new oats varieties were released during the year, but Vikota will probably be released in time for the 1955 season.

V.—Maize

The programmes for the year followed the same lines as last year and consisted of the hybrid maize and allied work at Njoro and Kitale, and the breeding for resistance to *Puccinia polysora* at the Coast.

A—Hybrid Maize and Allied Breeding Work

The Njoro season was a wet and cool one, hence the maize was slow in growing and the more inbred material was poor and yellow in the early stages and set poorly. However, after two previous years of drought (particularly 1953) this was a far better season and progress was made in making up for the damage sustained in those years. The programme at Kitale was again on a somewhat limited scale, since a third plant breeder is still awaited. Whilst the trial was not significant the crossing work was more successful.

Work at Njoro

A high proportion of the inbreeding work was based on 1952 material, since so much of the 1953 work failed because of the drought. A total of 310 cob rows were sown for inbreeding work and of these about one-third were selected for selfing. Of these cob rows 51 were inbred derivatives from Njoro maize, 64 from other Kenya maizes and 107 from imported varieties. The remainder were direct sowings of imported types, mostly made up of 66 varieties from a collection from Trinidad, passed to us by Dr. H. H. Storey, E.A.A.F.R.O., after seedling tests for resistance to *Puccinia polysora*. Whilst a few inbreds have now reached the S_7 generation the majority are less advanced, particularly in the group from "other Kenya maizes". This work will continue, but more faith is now placed upon rather quicker and safer methods of maize breeding than the classical hybrid maize techniques. It is intended that studies on those lines should receive special attention in the future.

This question of maize breeding methods was discussed by the meeting of breeders at the Specialist Committee meeting at Ukiriguru in Tanganyika in May and, as a result, a Maize Breeding Sub-Committee was set up to review the subject in detail and to provide a means of co-ordinating the individual programmes in the East African territories. A memorandum on three techniques used in work in this department was prepared for consideration by this sub-committee. By co-operating in this way, and by comparing results obtained at the different breeding stations using different breeding methods, it is hoped to be able to decide which is the most rapid and economic method suitable for producing

improved maize stocks under East African conditions. The production of improved self-propagating synthetic varieties is particularly needed for African areas, where hybrids would not be a workable proposition, at least in the immediate future. Indeed, it is probable that synthetics would greatly improve the maizes for European areas as well and would obviate the necessity for a supporting seeds organization required for hybrid maize growing.

The first synthetic produced was lost in the drought of 1953, but it was remade (though in slightly changed form) and multiplication has now reached some three bags of seed. As the basis for a second cycle of improvement, over 200 selfings in the best station-selected maize were made. These will be top-crossed by the synthetic for evaluation of their general combining ability in a trial in 1956. From the better lines a further synthetic will be made.

The first inbreds, which date back to pre-war years, were grown for crossing and purification. Seeds sets were extremely poor, due to the continually wet weather at pollinating time, and the work must unfortunately be considered a failure. It is apparent that such inbred lines are very susceptible to troubles from all possible sources, and that their maintenance and use is a continual struggle since the plants themselves show so little desire to survive.

Work at Kitale

The 11 fixed inbreds were sown for crossing and multiplication work and were crossed in all 55 possible combinations. The set of seed in certain combinations was poor, due to inherent characteristics of the lines involved, but the majority yielded sufficient seed for a single cross trial in 1955 from which it is hoped that double-cross yield predictions may be made. Surplus seed from selfings and crossing may have to be used to revive the Njoro work which has fared so poorly.

A trial of 81 top-crosses was laid down in order to evaluate the inbreeding lines which were held in abeyance till yield characteristics could be assessed. Yields varied from 12.33 bags per acre (of 200 lb. net) down to only 3.85 bags per acre, with a mean of 8.91 bags. Owing to the high error of the trial, no cross significantly exceeded either the mean yield or the yield of Kitale Selected. In the absence of statistical significance the top-ranking crosses will be taken arbitrarily for further work towards the production of a synthetic.

B—Puccinia Polysora

As was explained in the 1953 report, breeding was started at the Coast in that year with the object of transferring resistance to *P. polysora* into local maizes. The source of resistance was breeding material received from E.A.A.F.R.O., which in seedling tests had shown useful proportions of resistant plants. This material consisted of lines from Central America, mostly Columbian, where resistance to this rust disease has become established in native maizes because the disease is endemic. Recurrent backcrossing was planned to carry this resistance into locally adapted Kenya maize and in 1953 a large number of crosses was made as the first step towards this.

This year improved material was available from E.A.A.F.R.O., both inbred lines and crosses, in which the proportions of resistant plants was higher than in the earlier material. Accordingly 12 such AFRO inbreds and 11 F_1s from AFRO crosses were used in the programme at the Coast. In addition, a further 21 crosses from our own 1953 programme were chosen; these crosses involved three parents which work at E.A.A.F.R.O. had shown to be the most valuable as sources of resistance. *P. polysora* reached the plots as a natural attack and achieved a uniform infection over the susceptible pollinator rows of local white maize to which all the breeding material was crossed. Full results cannot

be given in this report, but three AFRO lines remained free of *polysora* and in others there was a high proportion of clean plants. Cobs from such plants were harvested for further breeding work.

VI.—Other Crops

No work with other crops was undertaken during the year, except for the multiplication of the one dwarf castor variety, Mauthner, at Kitale. The difficulty of harvesting such plants, and threshing their capsules mechanically, caused trouble, and until an answer can be found to this problem it is doubtful if such a crop can be utilized.

The dwarf sunflower variety Sunrise was multiplied on a field scale at Kitale, but was destroyed by *Sclerotinia sclerotiorum*.

VII.—Experimental Work

Soil and Wheat Quality Trial—Njoro

It had been noticed in the tests of wheat in 1950 that quality could vary considerably between different plots of one variety from the same field. Investigation of soil samples from the field in question was undertaken and, as a result, it was decided that a special trial would be laid down in 1954 to try to correlate soil and wheat quality data. This programme was drawn up in joint discussions with Unga, Ltd., and E.A.A.F.R.O.

The trial consisted of ten wheat varieties (five of them established and five new varieties of promise) in four replications, divided into three sub-plots in each case. Composite soil samples were taken from all 120 sub-plots, at two levels, giving 240 samples in all. These were taken just before sowing and sent for analysis. After harvest, grain samples from the 120 sub-plots were sent to Unga, Ltd., for wheat quality analysis. Whilst interpretation of results has not yet been possible, it may be stated at this stage that no clear trends emerge from the soil and wheat analyses. In particular it had been thought that sulphur figures might be interesting. In general, the wheat strengths of all varieties were extremely low, in spite of the fact that the list included certain varieties which are classed as of good quality; R 64, in particular, is a premium wheat.

In the following table a summary of yield figures and bushel weights is given and shows the wide range of yields:—

Table XII

Variety	Mean Bushel Weight	Yield (*bags/acre*)	Position
350 AA.5.B	62	10·4	1
360 F.8.D.3	60¼	9·5	2
Granadero Klein	59	9·3	3
318 AJ*	60	9·2	4
360 H*	59¾	8·9	5
360 F.8.X.6.A	59½	8·7	6
294 M*	59¾	7·4	7
Rhodesian Sabanero*	57½	6·8	8
R 64*	57¾	5·2	9
356 A.12.C	55⅔	4·4	10

*Established varieties.

VIII.—Publications

(1) "The 1954 Seed Maize Competition", *K.I.O. Fortnightly* and local Press.

(2) "Release of New Cereal Varieties—V", *East African Agricultural Journal,* Vol. XX, No. 2, October, 1954.

(3) "Release of New Barleys—1954", *K.I.O. Fortnightly* and local Press.

(4) "Cereals in Kenya—1955/56", *K.I.O. Fortnightly* and local Press.

(5) "Notes on the Naming of 'Kenya Farmer' Wheat", *Canadian Journal of Agricultural Science,* Vol. 34, No. 5, September–October, 1954.

IX.—Acknowledgments

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H. C. THORPE,
Senior Plant Breeder.

ANNUAL REPORT OF THE PLANT PATHOLOGIST (PLANT BREEDING), 1954

Cereal Diseases

Stem Rust of Wheat—Two New Forms

The presence of two new Stem Rust (*Puccinia graminis*) forms, K13 and K14, was confirmed. These forms were identified on material from the 1953 crop. In seedling resistance tests, K14 appears to be more virulent than any previous form, and can be expected to cause trouble in the future.

The reactions of these rust forms on the established differential wheat series are:—

Differential	K13	K14
Kenya Governor ..	1	3
Einkorn	3	1–2
B. 256.G	3	4
Reliance	0	3
58 F	4	4
Rhodesian Sabanero ..	4	3–4
117 A	3	3–4

In view of the arrival of these further rust forms this series has had to be expanded and the wheats 184.P.2.A.1.F and 367.BR.1.D.4.F have been selected for addition to the series. Their reactions to some of the earlier rust forms are not known. The full series now reads, for rusts K9–K14:—

Differential	K9	K10	K11	K12	K13	K14
Kenya Governor ..	0	2	2	3	1	3
Einkorn	2–3	2–3	2+	1	3	1–2
B.256.G	2–3	3	1–2	1	3	4
Reliance	3	0	0	;	0	3
58. F	3–4	3–4	3–4	1–2	4	4
Rhodesian Sabanero ..	3–4	3	3–4	3	4	3–4
117. A	2–3	;	3	3	3	3–4
184.P.2.A.1.F	2	0	;	0	1	1
367. BR.1.D.4.F	;	0	0	;	1	1

However, Rhodesian Sabanero will now probably be dropped from the series since it is fully susceptible to all the latter forms and thus contributes no useful information.

Wheat

Due to a rather cold, very wet and sunless period, Stem Rust (*Puccinia graminis*) made a late appearance and, at Njoro, some early maturing varieties completely escaped damage. Other varieties, however, were severely damaged, and in areas where planting is later severe losses were incurred, some field crops being so badly damaged as to be not worth the expense of harvesting.

The more recent Stem Rust forms were identified from the field, with K11 predominating. K9 and K12 were also prevalent: K6, first identified in 1940, appeared once. The new form K14, isolated in 1953 from the Kinangop, appears well established, having been identified on crops from Njoro and Eldoret, while K13, also from the 1953 crop, was found once only, on material from Kipkabus.

Due also to the season, Yellow Ear Rust (*Puccinia glumarum*) was much more prevalent than usual in the lower wheat growing areas, and extensively present in the higher. Over the country, this fungus caused severe damage. At the Plant Breeding Station some Egyptian varieties under cage trial were completely eliminated. The hitherto highly resistant variety 341, a popular wheat widely grown, was severely attacked, pointing to a new or new strains of *P. glumarum*. This emphasizes the need for work on this fungus in the same manner in which Stem Rust is being tackled. In fact, the balance seems to be shifting and, although Stem Rust is still the most important cereal disease, Yellow Ear Rust cannot be far behind.

Brown Leaf Rust (*P. triticina*), which is generally most severe in the lower and hotter wheat growing areas, was not prevalent and caused little damage.

Attacks by Take-all (*Ophiobolus graminis*) were extremely common, and the importance of this fungus increases yearly. In fact it is nearly impossible to find a crop in an established wheat growing area in the higher country in which Take-all is not present. Some crops were entirely destroyed and infections of the chronic Whiteheads type were frequently counted at over 20 per cent infection. Financial loss over the country due to this fungus must be heavy.

Pyrenophora tritici-repentis, identified first last year, appeared in damaging attacks in most areas. The fungus is well established and in some cases repeated its 50–75 per cent losses in attacked crops. Evidence now points to a certain degree of soil carry over, though for how long it will persist in the soil is not yet known.

Because of the unfavourable growing conditions, Foot Rot due to *Fusarium graminearum* caused more damage than usual. In general it occurred in patches but in one case from Njoro, when wheat had been planted after maize, the whole field was affected, blind and light ears occurring throughout the crop.

Helminthosporium sativum was, as usual, present. Glume Blotch (*Septoria nodorum*) was common, though only one severe attack was noted. In that crop, the top half of every head was found to be empty. *Septoria tritici*, uncommon and unimportant, destroyed a lot of leaf tissue in one crop from Molo.

Loose Smut (*Ustilago tritici*) should be watched. At present it is not prevalent, though it constitutes a menace. At the Plant Breeding Station, a small plot grown from Argentinian seed was found to be fairly badly infected; and new strains of the fungus brought in, in this way, could prove serious.

Xanthomonas translucens, causing Black Chaff, is probably more widespread than is realized. This year conditions favoured the organism and it could be found in most crops. It undoubtedly causes widespread, though usually minor, damage.

Seed infections were common, and from such "Black Point" grain *P. tritici-repentis*, *H. sativum*, *F. graminearum*, *Fusarium* spp. and *Alternaria* spp. were frequently isolated, together with many common saprophytes.

Barley

Leaf diseases have, in general, been severe and their appearance early. Leaf Blotch (*Rhynchosporium secalis*) could be seen in every barley crop in differing intensities, and a 60 per cent leaf death was common, Spot Blotch (*Helminthosporium sativum*) and Net Blotch (*H. teres*) were prevalent, and very heavy attacks of the latter on young plants caused the complete destruction of two crops. Mildew (*Erysiphe graminis*), uncommon in the field in Kenya, caused extensive leaf death in one crop, again a reflection on the weather. Stem Rust and Yellow Ear Rust were present. *Ophiobolus graminis* severely attacked one crop examined. Loose Smut (*Ustilago nuda*) is definitely on the increase, and has nearly destroyed the variety Glacier, which is particularly susceptible. However, a stock of seed with only minor infection has been saved by prompt treatment.

Oats

Stem Rust and Crown Rust (*Puccinia coronata*) were common. In some crops many blind ears were found, up to 40 per cent being observed. The cause was not determined. A single plant growing as a rogue in a crop of wheat was found infected with *O. graminis*. To date, there has been no record of oats being infected by this fungus in Kenya, and it was believed that the strain of the fungus capable of attacking oats was not present. However, in this one particular instance it would appear that an oat strain may have developed.

Maize

Rust (*Puccinia sorghi*) appeared very early in the season, but so far there is no record of the appearance of *P. polysora* in the higher areas. White Blight (*Helminthosporium turcicum*) was troublesome in some crops. Cob Rots were caused by *Fusarium graminearum*, *Fusarium* spp. and *Nigrospora oryzae*. The "Trans Nzoia" disease again caused damage and on one farm at least 10 per cent of the plants were killed. It was noticeable that the red stalked Kikuyu maize was much less severely attacked than the "farm maize". The causal organism is a species of *Fusarium*.

Publications

1. "Seedling Resistance and Mature-Plant Susceptibility of Wheat to *Puccinia graminis* found in Kenya". *Nature, Lond.*, 173, p. 779, 1954.

2. "A New Disease of Wheat in Kenya Caused by a Species of *Pyrenophora*". *East African Agricultural Journal*, XIX, pp. 225–229, 1954.

3. "Resistance to Take-all Disease in Kenya Wheat 131". *East African Agricultural Journal*, XX, pp. 120–121, 1954.

A. D. S. DUFF,
Plant Pathologist.

ANNUAL REPORT, COFFEE RESEARCH STATION, RUIRU

Rainfall Records at the Department's Coffee Stations—1952–1954

Stations for which data are given in tables below

A = Coffee Research Station, Ruiru.

B = Scott Agricultural Laboratories, Nairobi.

C = Anmer Estate, Kiambu.

D = North Kitito Estate, Makuyu.

E = Kitale Experimental Station.

	A	B	C	D	E
	inches	*inches*	*inches*	*inches*	*inches*
1952					
January	0·12	0·04	0·12	0·79	0·03
February	0·41	0·71	0·60	0·10	0·48
March	1·49	0·77	1·85	0·35	5·11
April	17·02	15·69	16·74	6·24	6·50
May	7·83	11·33	9·18	7·52	7·18
June	0·15	0·00	0·06	0·00	3·25
July	0·50	0·33	1·14	0·00	4·71
August	0·84	0·59	0·79	0·20	6·00
September	1·31	0·86	1·61	2·93	3·85
October	3·73	1·20	2·31	2·20	2·02
November	4·85	2·71	3·60	7·17	0·95
December	1·15	0·54	0·82	0·74	0·02
Total Inches	39·40	34·77	38·82	28·24	40·10
Total Days	109	87	107	81	149
1953					
January	0·53	0·86	0·69	0·98	0·15
February	0·00	0·00	0·00	0·37	0·28
March	2·53	2·08	2·24	2·80	0·42
April	5·01	5·13	4·28	5·28	7·00
May	6·11	7·06	7·50	5·80	7·04
June	1·13	0·69	1·24	0·42	4·73
July	0·85	0·60	0·63	0·15	2·27
August	1·54	1·14	1·77	0·81	6·81
September	0·93	1·56	2·66	0·00	0·32
October	3·73	1·92	4·75	2·46	3·15
November	4·24	5·73	6·03	9·84	1·61
December	1·26	1·22	1·18	2·15	1·12
Total Inches	27·86	27·99	32·97	31·06	34·90
Total Days	111	93	101	95	138

1954	A	B	C	D	E
	inches	*inches*	*inches*	*inches*	*inches*
January	1·09	1·40	0·64	0·00	0·42
February	1·26	3·82	2·15	0·37	2·17
March	0·12	0·11	0·22	1·32	3·09
April	11·41	9·84	10·62	12·37	6·07
May	6·44	14·36	6·85	10·95	5·39
June	6·79	1·67	2·43	1·23	4·62
July	1·54	1·58	1·09	1·00	6·99
August	0·66	0·31	0·69	0·28	7·71
September	0·24	0·32	0·31	0·06	6·18
October	0·54	1·25	1·05	2·21	0·84
November	4·40	5·12	5·14	7·18	1·19
December	1·72	1·05	0·72	2·73	1·29
TOTAL INCHES ..	36·21	40·43	31·91	39·70	45·96
TOTAL DAYS ..	116	100	103	98	133

The last annual report from the Coffee Research Station was published in 1951. It had been the intention to commence the publication of an independent annual report for this station with effect from 1952, the first issue of which was to have included a full record of all experiments and past work. In the prevailing circumstances this proved to be impossible because in the first 18 months of the Emergency the staff became heavily involved with Police Reserve duties, a situation which could not be avoided on a station situated as it was in the middle of one of the troubled areas. Every effort was made, however, to maintain and even increase, the programme of investigation and to step up the tempo of the extension work for obvious economic reasons. During this period also, calls on technical staff to survey and advise on coffee matters in the African Land Units were heavy. This was in connexion with the broad development plan for coffee in these areas. The present report goes a long way towards making up the deficiency in reporting and it is very heartening to look back over a period of very real progress in both the research and extension fields.

Mr. J. B. D. Robinson, Agricultural Chemist, assumed duty at Ruiru in May, 1953, in place of Dr. H. C. Pereira, who had previously transferred to E.A.A. & F.R.O. Dr. Pereira's work was mainly, though not entirely, in the field of soil physics and has been reported in previous annual reports as well as in scientific journals. His studies on grass mulches in coffee as a means of improving the acceptance of limited rainfall, conserving soil moisture and restoring soil structure have been of the utmost value to the coffee industry and the practice has been taken up by a large number of growers.

In a comprehensive cultivation trial and other studies, investigations by Dr. Pereira and Mr. Jones into the effect of weeds in coffee as competitors for soil moisture have included studies of possible implements to effect weed control. These studies have led to a very much fuller understanding of the factors involved and the practical implications which have emerged have been of great value. In co-operation with commercial interests a modified rotary cultivator has been evolved and carefully field tested. It is now ready for adoption by growers.

Mr. Robinson's main line of investigation is a full study of soil nitrogen both natural and applied under different field conditions and his work on this subject has already led to modifications in recommendations to growers. His work on chemical weed control holds promise of the successful application of this method to coffee and tentative field recommendations have been made for controlling weeds growing through mulches, a difficult practical problem of great importance. A rapid field method of determining the effective depth of coffee soils has been published and this will be of great value in connexion with farm planning and measures to increase the efficiency of production. Mr. Robinson's work on a cambered bed cultivation system for clay pan or vlei soils shows promise of bringing this type of land, at present useless, into agricultural utilization as a means of mulch production on coffee estates as well as for a range of other crops.

Mr. Rayner and Mr. Jones have continued research on anti-leaf-fall spraying and, although there is still much to elucidate in this complex problem, notable advances have been made. An important innovation during this period has been the inception of work with low volume "airblast" spraying equipment. The number of growers using annual anti-leaf-fall copper sprays has risen steadily.

Mr. Jones is responsible for all variety trials on the research station and substations and has also assisted field officers with the establishment of variety trials in all coffee districts of the Colony. In the African Land Units the cover of variety trials is very extensive and, both here and elsewhere, these trials are proving to be of the utmost value.

Mr. Rayner has been able to do some new work on Leaf Rust (*Hemileia vastatrix*) which has helped to clarify the field approach to the problem and made it possible for improved control recommendations to be issued. The 1951 outbreak of Coffee Berry Disease in Upper Kiambu has been previously reported; while the disease has not subsequently extended its range it is now permanently established in that district and has naturally caused great alarm to the industry. Though funds have been provided to finance a special team to investigate this problem it has so far proved impossible to obtain the necessary staff. Investigations have nevertheless been continued to the limit of the staff resources available.

In the entomological field the most important development has been Mr. McCrae's work with Dieldrin as a means of controlling the mealy bug attendant ant, *Pheidole punctulata*. The method evolved has given a degree of ant control never previously approached and has led to a reduction in the status of the Common Coffee mealy bug (*Planococcus kenyae*) to the level of a relatively minor pest.

A. R. MELVILLE,
Senior Research Officer i/c Coffee Services.

ANNUAL REPORT—ENTOMOLOGIST—1952-1954

Coffee Mealy Bug, *Planococcus kenyae* (Le Pelley)

General

During the period, mealy bug has been a pest of relatively minor importance and no outbreak as serious as that of 1950–51 has taken place. The fact that no serious successive droughts have occurred, have had no adverse effect on the parasites concerned in biological control: this, coupled with efficient banding methods against the attendant ant, *Pheidole punctulata,* Mayr., has prevented any widespread outbreak. In addition, growers have increasingly come to realize that mealy bug outbreaks have their origin on young vertical growth at the base of the tree and have usually taken steps to limit such growth to the minimum required for new multiple-stem cycles. Mealy bug continued to be limited to the coffee growing areas east of the Rift Valley.

Biological Control

Anagyrus sp. nr. *kivuensis* Comp. has continued in its role of the dominant species of the introduced parasites, but *Pauridia peregrina* Timb. *Anagyrus beneficians* Comp., *Leptomastidea jeanneli* Mercet. and *Leptomasix bifasciatus* Comp., have also been recovered from samples taken in the field.

Among the predators of mealy bug the Coccinellids *Hyperaspis* sp. nr. *senegalensis* Muls, *Hyperaspis* sp. nr. *delicatula* Muls. and *Chilocorus angolensis* Crotch. and several *Scymnus* spp. have been noticed. *Chrysopa* spp. have also been in evidence.

In the insectary the breeding of *Anagyrus* sp. ("*Small Anagyrus*") and three Cocinellids, *Hyperaspis senegalensis* Muls., *H. quadrilla* Muls. and *Scymnus* sp. nr. *alienus* Wse, has continued. These insects were obtained in Uganda in 1951. The breeding of *Anagyrus* sp. nr. *kivuensis* Comp. has also been continued. The following table shows the numbers of each species liberated during the three-year period:—

Table I

Species	Numbers Liberated		
	1952	1953	1954
A. kivuensis	22,801	40,724	19,616
Small Anagyrus*	1,314	2,453	6,407
H. senegalensis	—	967	2,930
H. quadrilla	—	—	200
Scymnus sp. nr. *alienus*	1,700	1,050	2,500

*Figures apply to females only, the male is impossible to distinguish from the male of *A. beneficians* with the naked eye.

None of these insects has yet been proved established in the field, except of course, *Anagyrus* sp. nr. *kivuensis,* which has long been of primary importance in controlling Mealy Bug.

Control of the Ant, Pheidole punctulata Mayr.

Experimental work on mealy bug has been mainly concerned with insecticides for the control of the attendant ant, *Pheidole punctulata* Mayr. In all experiments

described below, the various insecticides have been applied as liquids to the main stems of the trees from ground level to a height of 1 ft., so that the deposit forms a barrier to the passage of attendant ants from their nests in the ground to the Mealy Bug on the coffee tree. The practice has usually been to spray the insecticide on to the tree bases and the practice has come to be known as "spray-banding". The discovery of the efficiency of Dieldrin as an ant barrier in 1951 was followed by further experiments to determine in what form it could be best used, how best it could be applied and at what concentration. It has proved a difficult insecticide on which to obtain precise persistence data, as the mealy bug above the Dieldrin deposit at the tree bases has almost invariably disappeared before the insecticide became inactive, and the attendant ants therefore had no reason to attempt crossing the bands.

Dieldrin, used in 1951 at 1.5 per cent strength, gave excellent results: subsequent work in 1952 was aimed at reducing the concentration if feasible, but the interim advice to growers was to use it at the 1.5 per cent strength. A number of small experiments carried out in widely separated localities indicated that Dieldrin used at 1 per cent gave excellent control of ants, and that the emulsion form was more efficient than the wettable powder used at the same strength. The following table shows the results of an experiment carried out in the Donyo Sabuk area, where the performance of the emulsion at 1.5 per cent and 1 per cent Dieldrin concentrations were compared:—

	Number of Bands Crossed by P. *punctulata*			
Weeks after application	2	4	6	9
1·5 per cent Dieldrin	0	0	0	0
1·0 per cent Dieldrin	0	0	1	0
Controls (untreated)	Ant attended throughout			

In this experiment, 40 trees were banded with each concentration. By the end of the period all treated trees were completely clear of mealy bug.

Another experiment followed to compare greater dilutions of an 18.6 per cent emulsifiable concentrate of Dieldrin. The dilutions were 1 part of the concentrate in 20, 50 and 100 parts of water, which gave respective concentrations of approximately 0.88 per cent, 0.34 per cent and 0.17 per cent of Dieldrin. Adjacent plots, each of 36 trees infested with mealy bug, were treated with each concentration. Observations were continued for only four weeks, because the mealy bug had cleared by the end of that time.

The following table shows the results:—

	Total Number of Bands Crossed by P. *punctulata*		
Weeks after application	1	2	4
0·88 per cent Dieldrin	0	0	0
0·34 per cent Dieldrin	5	6	6
0·17 per cent Dieldrin	13	21	29
Controls	Ant attended throughout		

In July, 1954, a banding trial to compare the efficiency of Dieldrin, Endrin, Isodrin and Chlordane was commenced at the Coffee Research Station in a plot infested with mealy bug. All the insecticides were used at 1 per cent strength, the emulsifiable concentrate being diluted with water. Three days after application the bands were checked and renewed if ants were crossing them: this involved treating one of the Chlordane-banded trees and four of the Dieldrin-banded trees.

Owing to the erratic distribution of infested trees, plots of identical size were not used. Endrin and Isodrin were in short supply and only single plots of 23 trees were banded with each of these insecticides. Two plots were treated with Chlordane, involving 21 and 25 treated trees respectively, and two plots involving 21 and 23 treated trees, were treated with Dieldrin. Untreated trees were distributed at random in each treated plot to act as controls: 44 trees being used for this purpose. The experimental area was, in all, a plot of 20 × 38 trees planted 9 ft. × 9 ft. Observations were made until 1st November, after which the rains broke and largely suppressed the ant activity.

TABLE II

Weeks after application ..	PERCENTAGE OF BANDS CROSSED BY *P. punctulata*								
	1	2	5	7	8	9	10	11	12
Endrin 1 per cent	0	0	0	0	0	0	0	0	0
Dieldrin 1 per cent	0	0	0	0	0	2	2	9	11
Isodrin 1 per cent	0	0	0	0	22	30	48	57	65
Chlordane 1 per cent	2	4	4	7	7	28	43	54	54

A disadvantage attached to the use of the emulsion was that the deposit on the stems of the trees banded became invisible after it had dried. Growers found it difficult to check the progress of banding treatment, and the workers employed in applying the bands were liable to leave gaps through which the ants could pass. In March, 1953, several different dyes supplied by Messrs. African Explosives and Chemical Industries Ltd., were tested in order to find a colouring matter which would remedy this disadvantage. The following table shows the dyes used and their order of efficiency for the purpose: the dyes were dissolved in the emulsion after it had been diluted to 1.5 per cent Dieldrin concentration, except for Waxoline Blue, which was dissolved in the emulsion concentrate before the addition of water:—

TABLE III

Dye	Concentration	Order of Efficiency
Methylene Blue 2 BNS ..	1 lb. in 10 gal. diluted material ..	1
Victoria Blue BN 150 ..	1 lb. in 10 gal. diluted material ..	2
Methyl Violet 28 110 Lumps	1 lb. in 10 gal. diluted material ..	3
Rhodamine BS XQ1 ..	1 lb. in 10 gal. diluted material ..	4
Coomassie Violet	1 lb. in 10 gal. diluted material ..	5
Naphthalene Coir Scarlet B.	1 lb. in 10 gal. diluted material ..	6
Fluorescene LTS	1 lb. in 10 gal. diluted material ..	7
Waxolene Blue AS (Oil soluble)	1 lb. in 50 lb. emulsion concentrate ..	6

Subsequently it was found that Methylene Blue could be diluted to a much greater extent and still give a sufficiently good effect. It is now recommended that 2 oz. of Methylene blue be dissolved in 10 gal. of diluted material. The incorporation of the dye has been found greatly advantageous in ensuring that the trees are properly banded. Malachite Green was later tested on basis equivalent to Methylene Blue and was found to be an efficient substitute.

Methods of Applying Banding Insecticides

Application with a brush has the advantage of economy of material and application with a hand sprayer has also been found satisfactory. Both these methods, while normally efficient, are laborious and slow: operators have to encircle the trees in a crouching position resulting in fatigue and progressive lack of attention to the treatment of crannies and grooves running vertically in the stems of the trees. In 1953 Messrs. Pest Control Ltd. produced the "Pesco" spray-banding ring, a horseshoe-shaped lance carrying three jets, one at the apex of the horseshoe and one at either extremity directed inwards. The jets mounted on the ring are size No. 8002 "Teejets", which deliver flat cones of spray which strike the stem of the tree from three directions simultaneously. This instrument, used in conjunction with a pressure container, greatly enhances the speed and efficiency of banding infested trees. A certain amount of spray is also deposited on the ground around the tree and thus acts as an additional deterrent to the ants.

Growers are now advised to use this apparatus in order to accelerate the speed of banding treatment and thus suppress ant activity with the greatest possible speed.

The recommendation now made to growers is to dilute the 18.6 per cent emulsion concentrate, "Dieldrex 15", in the proportion of 1 part "Dieldrex 15" to 20 parts of water, to add Methylene Blue or Malachite Green at a rate of 2 oz. of either to 10 gal. of diluted material and to apply this to affected trees from ground level to a height of 1 ft. The bands should be inspected within two or three days and renewed if ants are crossing. After this, a weekly check of bands and weed contacts between the ground and the lower branches of the trees is all that is necessary to ensure efficient control of *P. punctulata* until the outbreak of mealy bug disappears.

Antestia, *Antestiopsis lineaticollis* Stal., and *faceta* Germ.

Except in cases where plantations had been neglected or where control measures were not taken, *Antestiopsis* spp. have not caused much trouble. Spraying with D.D.T. at 0.1 per cent strength has been widely used to control *Antestiopsis* spp., but caution has been advocated in regard to the use of this insecticide. Advice on the use of D.D.T. has been to use it only on populations of 10 *Antestiopsis* per tree and over, coupled with careful routine testing to indicate the blocks of coffee or parts of blocks carrying such high populations. D.D.T. can thus be applied only where it is needed. In addition, the staggering of D.D.T. applications has been advocated both in time and space so that interference with beneficial insects is reduced to a minimum. Pyrethrum powder dusting has been advised at a rate of 10 to 12 lb. per acre, for lower populations. In general, growers have been advised to carry out monthly routine tests on their estates and to control any population of *Antestiopsis* averaging over two per tree in the drier areas and one per tree in the wetter areas. Since it was shown in 1951 that B.H.C. spraying could induce undesirable tainting of coffee, this insecticide has been abandoned for use against *Antestiopsis*. Attention has therefore been directed to evaluating the effect of D.D.T. dusts and pyrethrum formulations on *Antestiopsis*.

Dusts Against *Antestiopsis* spp.

The initial experiment, using the drift dusting technique, was carried out in the Thika area. The applicator, a "Whirlwind Major" duster, was mounted on a tractor which ran along the coffee row while the machine emitted the insecticidal dust at right-angles to the line of travel. The dust, after losing its initial velocity, was carried by the wind through the coffee, where it either settled on the foliage and ground or was dissipated into the air. A low wind velocity was obviously desirable during dusting so that the dust would not be too rapidly dispersed. To this end dusting was completed before 0900 hours in all experiments.

Pyrethrum powder was used in the initial trial in order to determine the range of effectiveness of the technique. A five-acre block of coffee, where the average number of *Antestiopsis* (*mainly A. lineaticollis*, but a few *A. faceta*), was 68.6 per tree, was used for the test. The coffee was planted 9 ft. × 9 ft. Dusting runs were made in every 13th row of coffee. Forty-eight hours after dusting, the average number of *Antestiopsis* per tree had fallen to 7.3 over the whole block. The following table shows the counts at 48 hours after dusting, for each of the four runs of the machine through the 5-acre block: —

Table IV

Number of Rows from Duster	Average Number of *Antestiopsis* per tree			
	1st Run	2nd Run	3rd Run	4th Run
2		4		
3	5			
4			2	
6		2		
7	0			1
8			48	
9		3		7
10	14			
11			73	13
12		1		8 (1 tree)
13	21		18	16 (1 tree)
Total *Antestiopsis*	40	10	141	45

Eight trees were tested in each section treated by a single run of the machine, two in each row selected for testing, except for one tree in each of rows 12 and 13 in the block treated by the fourth run. Pyrethrum powder was used at an arbitrary rate in order to assess the range of the dust drift. In fact 22.4 lb. of pyrethrum powder, containing 0.92 per cent pyrethrins, was used per acre. From the figures above it appeared that the application began to lose its efficiency when approaching 8 rows from the machine.

In March, 1953, D.D.T./Diatomite dust was tested, applying a 5 per cent D.D.T. dust at 45 and 30 lb. per acre in two adjacent plots of 400 trees. Runs were done in every 10th row in single-stem coffee, planted 9 ft. × 9 ft., on an estate in Ruiru.

TABLE V

Time of Test	Average number of *Antestiopsis* per tree	
	30 lb. per acre	45 lb. per acre
Before Dusting	20	42
48 hours after Dusting	4·1	4·5
7 days after Dusting	0·9	3·0
14 days after Dusting	1·4	8·0

It appeared from these figures that the 5 per cent D.D.T. dust lost its toxicity to *Antestiopsis* about one week after application. A further trial, using the same dust formulation at a rate of 30 lb. per acre gave anomalous results, and further work is necessary to perfect the technique.

PYRETHRUM FORMULATIONS

At the Coffee Research Station experiments were done to test the efficacy of pyrethrum extract emulsions and pyrethrum powder against *A. lineatcollis*. A locally produced 25 per cent weight/volume pyrethrum extract was tested at three levels, 8 fl. oz., 5 fl. oz. and 2 fl. oz. per acre. The concentrate in all cases was diluted with lighting kerosene, the resultant solution being emulsified with Teepol and then diluted to the volume required with water.

The experiment using the 8 fl. oz. level was carried out as follows: Two square plots, each of 25 trees separated by 5 coffee rows were treated. Testing was carried out on a set of three of the trees among nine trees forming the centre of each treated plot on each occasion, such trees not being subsequently used. All of the nine trees were thus utilized by the time the third and final test at 48 hours had been done. Each tree received one pint of the diluted emulsion, applied with Eclipse No. 1 hand sprayers. Control trees were situated in nine groups of three trees in adjacent unsprayed coffee, a total of nine being tested on each occasion.

In the ensuing experiments where 5 fl. oz. and 2 fl. oz. were used respectively, two plots, each of 64 trees, were sprayed and two plots of similar size and adjoining the treated plots were used as controls. Five trees of the 16 forming the centre of each plot were tested on each occasion; such trees were not being used for further tests.

The following tables show the results of these experiments:—

TABLE VI

(1) 8 fl. oz. per acre

Time of Test	Treated Plots			Control		
	Average Numbers per tree (6 trees tested)			Average Numbers per tree (9 trees tested)		
	Nymphs	Adults	Total	Nymphs	Adults	Total
Before Spraying	1·0	10·8	11·5	10·8	4·4	15·2
24 hours after spraying ..	0·1	0	0·1	6·5	5·5	12·0
48 hours after spraying ..	0·5	0·3	0·8	6·7	6·3	9·0

TABLE VII

(2) 5 fl. oz. per acre

Time of Test	Treated Plots			Control		
	Average numbers per tree (10 trees tested)			Average numbers per tree (10 trees tested)		
	Nymphs	Adults	Total	Nymphs	Adults	Total
Before spraying	10·7	11·1	21·8	3·7	9·4	13·1
24 hours after spraying ..	0·3	0·8	1·1	3·4	7·2	10·6
48 hours after spraying ..	1·3	1·7	3·0	4·4	6·5	10·9

TABLE VIII

(3) 2 fl. oz. per acre

Time of Test	Treated Plots			Control		
	Average numbers per tree (10 trees tested)			Average numbers per tree (10 trees tested)		
	Nymphs	Adults	Total	Nymphs	Adults	Total
Before spraying	3·7	5·3	9·0	2·9	1·1	4·0
24 hours after spraying ..	0·4	0·8	1·2	6·9	5·0	11·9
48 hours after spraying ..	1·2	2·7	3·9	2·3	4·3	6·6

As soon as the spraying in each experiment had been completed, nymphal and adult *Antestiopsis* were collected from beneath the trees and were examined after 24 hours in order to determine what proportion of the population might recover. The following table shows the recovery rates:—

Rate of Application	Numbers of *Antestiopsis* Tested for Recovery			Percentage Recovery	
	Nymphs	Adults	Total	Nymphs	Adults
8 fl. oz.	33	61	94	0	0
5 fl. oz.	27	92	119	11·1	2·2
2 fl. oz.	23	59	82	26·1	2·4

Another experiment to compare the efficacy of pyrethrum powder and an emulsified kerosene extract of powder from the same source followed the experiments already described. The pyrethrum powder was dusted on to the trees at a rate of 10 lb. per acre. The extract was prepared by soaking an equivalent quantity of powder in one gallon of lighting kerosene for 24 hours. Five and a half pints of extract were recovered from the gallon used, this was emulsified with yellow soap and water, and further diluted with water to the volume required to apply one pint per tree. Three plots each of 64 trees were used for each treatment and the following tables show the results, based on average numbers of *Antestiopsis* taken over 15 trees:—

TABLE IX

Pyrethrum Powder—10 *lb. per acre*

Time of Test	Nymphs	Adults	Total	Average per tree
Before dusting	14	54	68	4·5
24 hours after dusting ..	0	2	2	0·1
48 hours after dusting ..	0	6	6	0·4

TABLE X

Pyrethrum Extract

Time of Test	Nymphs	Adults	Total	Average per tree
Before spraying	13	58	71	4·7
24 hours after spraying ..	1	4	5	0·3
48 hours after spraying ..	0	10	10	0·6

TABLE XI

Recovery rates are shown in the following table, counts being taken 24 hours after collection in the field following treatment.

	Nymphs		Adults		Total	
	Alive	Dead	Alive	Dead	Alive	Dead
Pyrethrum Powder ..	4	14	3	37	7	51
Pyrethrum Extract ..	5	20	0	71	5	91

Percentage Recovery

	Nymphs	Adults	Total
Pyrethrum Powder ..	22·2	7·7	12·1
Pyrethrum Extract ..	20·0	0	5·3

At the time that these experiments were done (April, 1953), the cost of the 25 per cent pyrethrum extract was Sh. 820 per gallon. The cost of this material at the 8, 5, and 2 fl. oz. levels per acre would therefore be Sh. 41, Sh. 25/60 and Sh. 10/25 respectively. The cost of pyrethrum powder was Sh. 2/16 per lb., an application of 10 lb. per acre would thus cost Sh. 21/60 for material. The emulsification of the extract, although adding to costs, would enable growers to utilize spraying machines on a wider range of pests and would enable them to dispense with persistent insecticide foliage sprays against *Antestiopsis*. Pyrethrum emulsion

spray has not been tried on a field scale, and further work is necessary to devise a suitable routine method of formulating the emulsion. A spray based on a product of known pyrethrin content would be of advantage, as pyrethrum powder normally used has the reputation of variable effectiveness.

Coffee Lacebug, *Habrochilà placida* Horv.

This insect has continued to cause trouble in some areas west of the Rift Valley. Outbreaks have followed D.D.T. spraying applied for the control of *Antestiopsis*, the D.D.T. destroying the balance between *H. placida* and its predator, *Stethoconus* sp., which normally controls it.

Advice to growers experiencing outbreaks of this insect has therefore been to avoid the use of D.D.T. sprays, to use pyrethrum powder against *Antestiopsis* spp. and to use a nicotine/soap spray against *H. placida* when it occurs in small localized areas, as normally happens. D.D.T. dusts, applied as in the *Antestiopsis* experiments described above, would possibly give good control of large infestations while not affecting too drastically the balance between *H. placida* and *Stethoconus*. No experimental work on these lines has, however, been done.

Coffee Thrips, *Diarthrothrips coffeae*, Williams

While in this period conditions have fortunately not been conducive to severe outbreaks, control measures have had to be taken. Such measures have been spraying with paris green/molasses/lime mixture, or spraying D.D.T. at 0.1 per cent strength.

In March, 1954, drift dusting experiments against Thrips were carried out, using the Whirlwind Major dusting machine. The first experiment at the Coffee Research Station was to determine the extent, in terms of numbers of rows of coffee from the machine, to which a Thrips population could be limited to under 100 Thrips per 100 leaves, using 5 per cent D.D.T. dust at 30 lb. per acre. The following table shows the results:—

Table XII

No. of rows from Dusting Machine	Thrips/100 leaves before treatment	Average No. of Thrips/100 Leaves						
		Days since dusting						
		1	3	6	10	15	23	27
2 (4 Reps.) ..	115	4	12	18	5	9	7	4
4 (3 Reps.) ..	115	10	27	37	14	11	34	25
6 (4 Reps.) ..	115	12	33	60	48	13	110	50
10 (1 Plot) ..	115	21	52	62	76	23	138	154
14 (1 Plot) ..	115	18	66	109	127	68	204	98
18 (1 Plot) ..	115	26	76	115	121	84	137	107
Control ..	291	275	157	134	153	271	—	—

On the basis of these figures it was considered that satisfactory control of Thrips could be achieved by running the machine in every 8th row and that this would give control for three weeks. The experiment was carried out in coffee planted 8 ft. × 8 ft., so the machine had a range of effectiveness of 64 ft. This corresponds to a range of 7 rows of a 9 ft. × 9 ft. planting, or 6 rows in a 10 ft. × 10 ft. planting interval.

This experiment was followed by another, to determine whether 5 per cent D.D.T. dust was altered in efficacy by varying the filler. Two formulations were used, in the first talc was used as a filler, in the second, Eburru Clay. The dusts were applied with the Whirlwind machine at a rate of 30 lb. per acre on single-stem coffee planted $8\frac{1}{2} \times 8\frac{1}{2}$ ft.

A single rectangular plot of 30 × 110 trees was treated with each dust formulation. The dusting machine was run in every 10th row parallel to the long axis of the plot. The plots thus required three dusting runs each. Counts of Thrips per 100 leaves were taken in the 2nd, 6th and 10th rows from each dusting run: the figures shown in the table below are therefore averages of three counts. The table shows the results of the experiment:—

TABLE XIII

D.D.T. in Eburru Clay

Time of Count	Row	Thrips per 100 leaves	Plot average Thrips/ 100 leaves
Before Dusting	—	—	118
4 days after dusting	2	37	
	6	75	72
	10	104	
8 days after dusting	2	67	
	6	120	116
	10	162	
14 days after dusting	2	64	
	6	156	125
	10	154	

D.D.T. in Talc

Time of Count	Row	Thrips per 100 leaves	Plot average Thrips/ 100 leaves
Before dusting	—	—	159
4 days after dusting	2	19	
	6	37	34
	10	45	
8 days after dusting	2	41	
	6	77	74
	10	105	
14 days after dusting	2	25	
	6	75	58
	10	74	

From the figures it can be seen that the D.D.T./talc formulation was more efficient than the D.D.T./Eburru Clay formulation. This applied both for initial kill and control thereafter.

White Stem Borer, *Anthores leuconotus* Pasc.

White Borer continued to do damage to coffee in the Makuyu, Maragua, Mitubiri and Donyo Sabuk areas. The distribution of the insect has not altered, but it has become a pest in the lower altitudes of the Teita Hills where coffee has again been planted. Campaigns in the first-mentioned districts were conducted by the Department in 1952 and 1954. Plans for the 1953 campaign had to be abandoned owing to the State of Emergency. The control method has continued to be as described in the Annual Report for 1951. In October, 1953, a field experiment to test the efficacy of spray-banding with Dieldrin was commenced, but the population of *A. leuconotus* was found to be so low when the plots were examined that no valid conclusions could have been drawn, and the experiment was discontinued. The experiment was based on results achieved by the Coffee Research Station at Lyamungu in Tanganyika, and it had been hoped to confirm the value of this method for the control of White Stem Borer. In August of 1954 three trees containing *A. leuconotus* larvae were brought to the Coffee Research Station from Teita. These were kept in quarantine until adult bettles commenced to emerge. At this time they were spray banded with "Dieldrex 15" diluted 1 : 20 with water. Adult beetles emerging subsequently from these trees were observed to be very sickly and incapable of co-ordinated movement. Insufficient material was available to perform a critical experiment, but this observation indicated the potential value of a Dieldrin deposit placed on the lower 18 in. of the main stem of the tree for incapacitating emerging adults.

Other Coffee Pests

Yellow-Headed Borer, *Dirphya princeps* Jord.

This insect has not assumed pest proportions during the period except for a few localized outbreaks. In April, 1952, a 40-acre block of coffee on an estate in the Thika area was heavily infested. The coffee in this instance was growing on very shallow soil, a factor inducing lack of tree vigour and greater liability to attack by such pests. Fumigation of the larvae in their tunnels with ethylene dichloride/carbon tetrachloride mixture in the proportions of 75 per cent ethylene dichloride to 25 per cent carbone tetrachloride has been advised in cases where control measures have been necessary.

In October, 1954, the Teita Hills were visited in order to investigate the incidence of *D. princeps,* which was formerly a major pest of coffee in that area, and was thought to be re-establishing itself on African-grown coffee. It had not yet assumed serious proportions, but in view of the past history of this pest in Teita, the greatest care will have to be taken in the future.

Black Borer, *Apate monachus* Fabr.

This insect did slight damage by boring in coffee stems on many coffee estates throughout Kenya, but never assumed serious pest proportions. Fumigation of the adults in the stems of attacked coffee has been advised as for Yellow-Headed Borer above.

In 1954 a series of photographs of the above-mentioned borers and the damage they do was prepared and sent to departmental officers dealing with coffee growing in the African reserves.

Leafminers, *Leucoptera coffeella* Guer., and *L. caffeina* Washb.

Leafminers have attracted more attention as pests of coffee, possibly because outbreaks sometimes appear to have been induced by D.D.T. spraying, the D.D.T. destroying parasites of Leafminer larvae and possibly because growers have been watching for outbreaks to follow such spraying for Coffee Thrips or *Antestiopsis*

A serious outbreak of *L. caffeina* started on an estate in Upper Kiambu in September, 1953, and an outbreak of *L. coffeella* caused serious defoliation on 10–15 acres of coffee in Ruiru in November, 1954. No control method was recommended as it was felt that the use of poisonous organic phosphorus insecticides involved too much hazard to estate labour who would have to apply them, even though control of Leafminers might be possible with such substances. Work has been started on the parasite complex of these Leafminers in order to gain more understanding of the reasons for outbreaks and work with insecticides continues.

Leaf-Eating Caterpillars

A few localized outbreaks of *Epicampoptera* (*Metadrepana*) *andersoni* Tams. were reported from areas west of the Rift. An outbreak of *Niphadolepis alianta* Kersch. occurred over an area of 30 acres on an estate in Makuyu in June, 1953, causing serious defoliation. The larvae of this insect have been noticed to occur together with those of *Parasa vivida* Walk. in cases where the latter has been the primary cause of damage. In December, 1954, an outbreak of *P. vivida* occurred on several estates in the Thika and Ruiru areas, serious defoliation being caused by it. Spraying of foliage with D.D.T. at 0.1 per cent concentration or with arsenical sprays, gave good control. The larvae of *P. vivida* also proved susceptible to pyrethrum powder dusting at a rate of 10–12 lb. per acre. Parasite activity controlled an outbreak on one estate in the Thika area before serious defoliation occurred.

Tip-Stem Borer, *Tortrix* (*Cacoecia*) *occidentalis* Wlsm.

This insect has caused damage, usually of minor importance, to the tips of young multiple-stem heads, more especially in the coffee at higher altitudes (6,000 ft.). The larvae have also been demonstrated to attack coffee berries in much the same manner as does Coffee Berry Moth. A Tip-Stem Borer causing serious damage in Teita is under investigation but it may not be this insect.

Coffee Berry Moth, *Thliptoceras octoguttale* Feld.

This insect has frequently been reported doing damage to coffee berries. The damage has usually been of a minor nature, but has on occasion alarmed growers not familiar with it. No control measures have been advocated for the insect as the damage is usually noticed after the larvae have pupated. As the larvae are protected within the cherry it is difficult to control them. It is nevertheless considered that this insect is often beneficial, in that it normally attacks berries which should in any case be removed in order to reduce crop strain. There may also be some connexion between D.D.T. spraying and more than usual severity of damage by this insect.

Green Scale, *Coccus africanum* Newst.

This insect did not cause any serious trouble in 1952 or 1953 but fairly serious attacks developed on some estates in the Thika and Ruiru districts towards the end of 1954. Control measures recommended were either spraying the infestation with oil emulsions or banding the trees against *Pheidole punctulata,* or both.

Insecticide Taint Trials

A further trial of B.H.C. formulations was carried out in 1952 to gain further information on the connexion between B.H.C. and bricky flavour. All these insecticides were applied as foliage sprays at recommended strengths, once after the long

rains and twice after the long rains. The following table shows the results, which largely confirm the findings reported in 1951:—

TABLE XIV

Insecticide	No. of Applications	Liquoring reports on 4 samples per application	Remarks
Lindane Wettable Powder 6·5 per cent gamma isomen.	1	2 tainted: not bricky ..	Remaining samples not bricky
	2	1 tainted: not bricky ..	
Agrocide Wettable Powder.	1	1 tainted: not bricky ..	,,
	2	3 tainted, one possibly bricky.	
Gammalin Emulsion Concentrate 10 per cent gamma isomen.	1	3 foul with bricky flavour, 1 very bricky.	,,
	2	2 foul with bricky flavour, 2 very bricky.	
Lindane Emulsion Concentrate.	1	2 slightly bricky ..	,,
	2	1 bricky, 1 very bricky, 1 foul with bricky flavour.	
Control	Not sprayed	No bricky flavour mentioned.	

Following experience with "bricky flavour" induced by B.H.C., taint trials were carried out with chlordane, Dieldrin, Endrin and Isodrin in 1953. No taints were imparted to coffee by any of these insecticides whether they were used at rates in excess of those normally used, as foliage sprays or as ant barriers. No reports of tainting have otherwise been heard from any of the growers who have been using either Dieldrin or chlordane for control of *Pheidole punctulata* Mayr. in estate practice.

GENERAL

A great deal of work has been done towards building up a comprehensive collection of the entire insect complex of the coffee crop. This has included not only the collection of the actual pests, but also of their natural enemies. In connexion with identification of insect material, the help of the Commonwealth Institute of Entomology is gratefully acknowledged. Mr. de Lotto, the specialist on taxonomy of Coccidae at the Scott Agricultural Laboratories, has rendered most valuable service in identifying numerous scale insects and Mealy Bugs collected on coffee and other host plants during the period. Acknowledgment is also made of the help given by firms dealing in insecticides, among whom have been the Shell Chemical Distributing Company of East Africa, Messrs. African Explosives and Chemical Industries (E.A.) and Messrs. Pest Control Ltd. Many growers have provided facilities for experimental work on insect pests, and without their co-operation, and at times forbearance, much less information on insect pests and insecticides could have been obtained.

D. J. McCRAE,
Entomologist.

REPORT OF THE AGRICULTURAL OFFICER (COFFEE SERVICES) FOR THE YEARS 1952 AND 1953

Tonic Copper Spraying

Copper Spray Trial I

The design, treatments and preliminary results of this trial were described in the Annual Report for 1948. Although the spraying treatments were last applied in May, 1951, records were continued for a further two years in order to assess the residual effects of the various spray treatments. The table below summarizes these effects alongside those when treatments were applied during the previous five years.

Table I

Yield Summary—in Cwt. of Cherry Per Acre

Group	Treatment	Sprays Applied			No Spraying	
		First year	Second year	4 years' total		
		1947	1948	1948–51	1952	1953
Control	No Spray	31·1	12·8	95·2	11·1	76·4
Type of Spray ..	Carbide	33·7	34·1	150·5	24·9	76·7
	Per cent of control ..	108	268	158	225	100
	Burgundy	35·5	38·5	158·1	30·5	74·4
	Per cent of control ..	114	302	166	276	97
	Perenox	31·0	36·7	159·2	28·4	75·6
	Per cent of control ..	100	288	167	257	99
Concentrate of Spray	1 per cent	36·4	31·9	149·4	20·4	79·5
	Per cent of control ..	117	251	157	185	104
	2½ per cent	35·1	40·5	167·2	29·9	78·0
	Per cent of control ..	113	318	176	270	102
	4 per cent	28·7	36·9	151·3	33·5	63·0
	Per cent of control ..	92	289	159	303	82
Rate per tree ..	2/3 pints	32·8	33·7	151·0	22·4	79·5
	Per cent of control ..	105	264	159	203	104
	4/3 pints	34·0	39·2	161·0	34·5	74·5
	Per cent of control ..	109	308	169	312	98

In 1952 the residual effects of the previous five years' spraying were profound: treatments exerted an influence on yield to a similar degree to that which prevailed in 1948. In 1948 this was due to the creation of a more favourable leaf/crop ratio during 1947, when seasonal leaf-fall was much reduced by copper sprays without causing a compensating increase in crop. Hence crop strain and carbohydrate exhaustion were prevented by copper sprays, allowing a good crop to be borne in the following year. A parallel situation did not arise in 1951, when sprayed trees yielded an average of 14 cwt. of clean coffee per acre compared with 10 cwt. per acre from the unsprayed controls. Nevertheless, sprayed trees suffered less die-back and, consequently in 1952, were able to bear a crop two to three times greater than control. Since crop strain was not alleviated by spraying in 1952 an inversion of the cropping pattern was expected to occur in the following year. As the table shows, heavy crops were borne throughout the trial except where 4 per cent sprays had been formerly applied. A crop of such weight, borne in a year of low rainfall, imposed heavy strain on the trees and, by comparison with adjacent trees bearing a similar crop,

the withholding of a "tonic" spray proved abnormally detrimental. After the crop was picked an estimate of defoliation and die-back was attempted by allotting a visual score to individual trees. This showed that two-thirds of the trees were nearly leafless, but no differences attributable to the former spray treatments were significant. From the foregoing it is concluded that there are no grounds for the belief that "tonic" copper spraying leads to harmful long-term effects or to subnormal cropping if the spraying is allowed to lapse.

Power-driven Machinery

During 1953 two methods of applying copper were investigated, viz.: —

(*a*) In the last decade tractor-drawn sprayers, emitting a high volume spray under high pressure, have been increasingly used to apply fungicidal solutions to coffee (i.e. for anti-leaf rust and anti-leaf-fall sprays). A series of tests which was undertaken before and after the long rains showed that an excellent underleaf cover could be achieved with an "air-blast" machine, utilizing low pressure and low volume of spray. At 60 gallons per acre the cover of fungicidal deposit exceeded that previously achieved by any other means. As a result of these tests a long-term trial was planned and initiated in May, 1954, to compare the "air-blast" machine with the standard high-volume, high-pressure sprayer for control of seasonal leaf-fall and its consequent effect on yield.

(*b*) Power-driven dusters, which project a swathe of copper fungicide dust, have been operated with success to control fungus diseases of some other plantation crops. For this reason it was thought that the dusting method might be a suitable and inexpensive means of applying copper fungicides to coffee. Small-scale trials which were undertaken in 1953 showed a poor deposit of dust on the lower side of the foliage. Since then more exacting trials have confirmed this.

Cultivation Trial

The results of tillage studies, of which this trial formed the basis, were submitted for publication as two papers during 1954—(1), (2).

In January, 1952, after the trial had been operating for five years, the treatments were modified and the scope of the trial was reduced to six replicates of a 3 × 3 design to test the factorial combination of the following treatments: —

(*a*) *Three Types of Implement*: —

Hand-fork, disc harrow and disc plough, used to a depth of 3 in. to 4 in.

(*b*) *Three Weed Controls*: —

(1) Clean weeding.—Weeds controlled wherever necessary during the rains.

(2) Slashing.—Weeds slashed wherever necessary during the rains.

(3) Tall Weeds.—Weeds not controlled during the rains.

In all three treatments weeds were turned in at the onset of the dry season. Each of the 54 main plots were split for assessing the effect of one *ndebe* (four-gallon tin) of *boma* manure per tree, applied just before the long rains. In effect, therefore, the depth of tillage contrasts and the subsoiling treatments were discarded; the experiment was also reduced in size by a third, to 54 plots. Following

the 1951 crop, conversion to a new cycle of multiple-stem was commenced by removing two of the three heads, cutting up the third, and selecting three suckers per tree. Yields for the subsequent two seasons are given in Table II below:—

TABLE II

Yield Summary—in Cwt. of Clean Coffee Per Acre

1952 Crop	Clean weeded	Slashed	Tall weeds	Total
Hand fork	5·03	2·32	2·61	9·96
Disc harrow	3·44	2·70	3·11	9·25
Disc plough	4·01	3·36	2·10	9·47
TOTAL	12·48	8·38	7·82	
1953 CROP				
Hand fork	5·17	4·00	2·74	11·91
Disc harrow	5·11	4·03	3·43	12·57
Disc plough	4·27	4·55	2·91	11·73
TOTAL	14·55	12·58	9·08	
TWO YEARS' CROP—1952–53				
Hand fork	10·20	6·32	5·35	21·87
Disc harrow	8·55	6·73	6·54	21·82
Disc plough	8·28	7·91	5·01	21·20
TOTAL	27·03	20·96	16·90	

Mean Yield of Subplots—Response to "Boma" Manure—in Cwt. of Clean Coffee Per Acre

	+C	−C
1952	3·76	2·60
1953	3·98	4·08
TOTAL ..	7·74	6·68

Several consistent differences in yields appear in Table II, namely:—

(*a*) In the marginal totals there are clear and consistent differences between the weed control treatments: clean weeding>slashing>tall weeds. The improvement in crop as a result of controlling weed growth during the rains was considerable, being 23 per cent and 59 per cent higher, in the aggregate of two years, than slashing and uncontrolled weeds respectively.

(*b*) No overall differences between implements appear.

(*c*) On plots which were forked or disc-harrowed clean weeding was clearly the best weeding policy.

(*d*) Where weeds were turned in by ploughing, unchecked weed growth during the rains led to poorer crops than slashing or clean weeding, which were of equal merit.

(*e*) The relative merits of the three implements, judged by crop yields, appear to depend upon the weeding policy, in particular—

(1) for clean weeding the hand fork was the best implement;

(2) where the weeds were slashed the plough was slightly superior to the hand-fork for the end-of-season weeding;

(3) for killing weed growth at the end of the rains the disc harrow was the best implement.

(*f*) In 1952, for the first time, *boma* manure produced an apparent response of 45 per cent more coffee than the untreated controls. This was not reproduced in 1953, when differences in yield were negligible.

Since many of these differences did not appear during the first cycle of pruning (i.e. in the first five years of the experiment), the truth of their import should await confirmation in subsequent seasons. The very large differences brought about by the varying degrees of weed control have become indisputably evident in the rate of growth of the multiple-stem heads during the first two years of the current cycle; yields are now a reflection of the size of the trees and are not necessarily the result of differences in moisture conservation. It was mainly to the latter that yield differences were attributed in the previous cycle.

Trials with Rotary Tillage Implements

Field results from the cultivation trial, conjoined with soil structure studies over a period of five years, demonstrated that a policy of moderate clean-weeding (during the rainy seasons) should be adopted in the drier coffee areas, and for this purpose a hand-fork should be used. The reasons supporting this conclusion were as follows:—

(1) Whether the implement were a hand-fork or a tractor-drawn disc harrow or plough, if weeds were uprooted whenever they reached a height of 6 in. to 9in. much greater yields were obtained than when slashed at the same stage or left until the end of the rains.

(2) For clean-weeding the hand-fork was the best implement: yields were 15 per cent higher (equivalent to one cwt. of clean coffee per acre per annum) than from the other two implements.

(3) The hand-fork caused less deterioration in the structure of the surface soil, measured in terms of free-draining pore space and percolation capacity.

(4) The soil surface was less subject to the erosive force of rainfall when clean-weeded by hand-fork; the disc harrow or plough inevitably leave off-contour furrows which are conducive to soil erosion.

When the advantages of weeding by fork were appreciated a tractor-drawn implement was sought which would reproduce the action of the hand-fork and leave the surface in a similar cloddy condition. Towards this end modified versions of a rotary hoe were tested. In 1953 a simple modification of a standard rotary hoe was obtained and tested: this implement appeared to be capable of producing the rough tilth of the hand-fork. Subsequent field tests confirmed this impression and a long-term yield trial was started in December, 1953, in which the new implement was compared with the hand-fork in its effect on soil structure and tree yields.

Pruning Trial

The details and results of this trial have been given in previous Annual Reports. The comparative yields of the four pruning systems under trial since regeneration (in 1945) from debilitated single stem are given in Table III:—

TABLE III

Yield Summary—in Cwt. of Clean Coffee Per Acre

Year	Multiple Stem	Single Stem (uncapped)	Single Stem (capped)	Single 2-stem (uncapped)	Significant Difference P=0·05
1946 ..	2·31	1·59	0·58	2·09	0·4
1947 ..	13·55	6·15	5·82	10·01	1·4
1948 ..	2·05	0·98	1·43	0·72	0·7
1949 ..	5·79	3·86	3·57	3·09	1·0
1950 ..	1·25	2·99	1·60	1·50	1·5
1951 ..	15·17	15·89	16·40	17·45	1·9
1952 ..	0·09	3·16	2·04	1·35	—
1953 ..	3·04	21·06	21·35	22·13	—
Mean yield per annum	5·41	6·96	6·80	7·29	—
Per cent of mean yield	82	106	101	111	—

The low yield of multiple-stem during the last two years is most marked; whereas multiple-stem showed an advantage of 0.9 to 1.8 cwt. per acre per annum at the end of six years, after eight years the mean yield was lower than the single-stem systems by a difference of 1.4 to 1.0 cwt. Since the multiple-stem trees were converted after the 1951 crop to the next cycle light crops in the following two years were to be expected. Apart from this factor all the single-stem trees bore excessive crops in 1953 and suffered severely from the strain of overbearing in a year of poor rainfall.

Variety Trials—Anmer Estate, Kiambu

The field layout of both trials was fully described in the 1948 Annual Report. During the period under review the trials were concluded, their restricted

design having fulfilled the objects for which it was intended. Yields since 1948 are summarized in the tables below:—

Trial I.—Planted in 1938; spacing 8 ft. × 8 ft.; pruning—single stem.

TABLE IV

Yields in Cwt. of Cherry Per Acre

Selection	1948–50 3 years' total	1951	1952	1953	TOTAL FOR 6 YEARS 1948–53	
					Yield	Per cent of control
SL. 3	82·6	58·7	65·7	18·3	225·3	61
SL. 9	188·5	42·4	228·5	15·3	474·7	128
SL. 14	186·5	76·8	193·6	53·5	510·4	137
SL. 17	200·8	54·9	217·4	9·1	482·2	130
SL. 28	172·0	44·3	190·0	1·2	407·5	110
SL. 30	189·6	32·0	121·3	12·3	355·2	96
SL. 34	176·7	61·2	202·1	4·4	444·3	119
J 2 D	170·3	71·3	160·8	42·8	445·2	120
Kenya Selected	183·1	73·2	192·2	62·7	511·2	137
Control ("French Mission")	134·9	47·8	185·2	3·9	371·8	100

Thus the high-yielding ability of SL.9, SL.14, SL.17 and Kenya Selected has been maintained since 1951, when these selections were superior to the other selections in the trial.

Trial II.—Planted in 1942; spacing—8 ft. × 8 ft.; pruning—single stem.

TABLE V

Yields in Cwt. of Cherry Per Acre

Selection	1948–50 3 years' totals	1951	1952	TOTAL FOR 5 YEARS 1948–52	
				Yield	Per cent of control
SL. 10*	77·1	94·0	98·2	269·3	111
SL. 33*	25·4	35·8	126·9	118·1	78
KIT 37	41·3	82·2	70·2	193·7	80
KIT 61	47·5	60·5	57·5	165·5	68
KIT 85	15·2	54·3	32·4	101·9	42
KIT 145	46·4	36·1	145·7	228·2	94
KIT 251	30·7	47·9	127·5	206·1	85
M 83	42·1	57·0	133·5	232·6	96
M 65	41·3	72·5	60·9	174·7	72
M 6*	31·2	68·4	30·7	130·3	54
Control (SL. 28) ..	63·4	74·3	104·3	242·0	100

* = Mean of four trees. Control = mean of 32 trees. All other selections are means of eight trees.

The heavy yields recorded by most selections in 1952 were notable, especially in view of the heavy bearing in the previous year. The margin of superiority of SL.10 and Control after three years was reduced by the yields of the last two years (1951 and 1952).

Manurial Trial—I

The results which have been derived from this trial were published in 1954 [3] and, as part of a comprehensive report, the first five years' results (1947–51) were included. When the fifth year's records had been analysed it became clear that there were good reasons for modifying the design and scope of the trial. At this stage it was possible to conclude that neither Uganda rock phosphate nor soda phosphate (applied as annual dressings of 3½ cwt. and 2 cwt. per acre respectively) had improved the quantity or quality of crop. Furthermore, it was concluded that:—

(*a*) Cattle manure had not increased yields when applied at either 3½ or 7 tons per acre per annum.

(*b*) Sulphate of ammonia at 1 cwt. per acre per annum had not affected yields, but at 2 cwt. per acre yields were greater in two of the five years and greater by 7 per cent in the five-year aggregate totals.

(*c*) In 1951 a significant increase in yield, due to a dressing of 2 cwt. per acre of sulphate of ammonia, was completely eliminated by the addition of 7 tons per acre of cattle manure. The pattern of the N × C interaction was such as to suggest that the form of cattle manure applied was deficient in nitrogen.

The manure used in the trial was made by yarding cattle under cover at night on dry Napier grass. When the manure was removed from yards it was turned down a series of open concrete stages to break it down to a suitable physical consistency. To overcome the nitrogen deficiency it was considered necessary to cover the manure while it was on the concrete hillside stages to protect it from the deleterious effects of rain and direct sunlight. It was thus intended that the experiment should be continued, using cattle manure of adequate nitrogen content. Three of the four replicates were discontinued and, in the fourth, only the original levels of nitrogen and manure were to be compared. Unfortunately, funds have not been available to provide an overhead cover for the concrete hillside stages and manure has been finished in the open, as it was prior to 1952. In April, 1952, all plots of the fourth replicate were given a blanket dressing of 3 cwt. per acre of Uganda rock phosphate and 2 cwt. per acre of soda phosphate in order to neutralize any residual effects of differential phosphate dressings. At the same time the first steps in conversion to multiple stem were taken: sucker growth was encouraged by removing all primary branches on the eastern side of the tree. Thereafter the trial became a simple factorial, in three replicates of a 3 × 3 design, to compare the treatments:—

(*a*) Nitrogen, as sulphate of ammonia, at nil (N_0), 1 cwt. (N_1) and 2 cwt. (N_2) per acre applied early in the long rains.

(*b*) Cattle manure applied immediately before the long rains at nil (C_0), one *ndebe* per tree (C_1) and two *ndebes* per tree (C_2). One *ndebe* per tree, in this case, is equivalent to 3½ tons per acre.

Crop yields for the two years after conversion are shown in the following table:—

TABLE VI

Interaction of Nitrogen and Cattle Manure—Yields in Cwt. of Clean Coffee Per Acre

Year	Nitrogen	Cattle Manure			Mean
		C_0	C_1	C_2	
1952	N_0	3·86	3·31	5·99	4·39
	N_1	4·30	5·61	6·98	5·63
	N_2	5·11	5·45	6·97	5·84
	Mean ..	4·42	4·79	6·64	5·28
1953	N_0	10·72	11·31	9·69	10·57
	N_1	10·83	9·69	8·88	9·80
	N_2	10·33	9·89	9·82	10·01
	Mean ..	10·63	10·30	9.46	10·13
2 Years: 1952–53 ..	N_0	14·58	14·62	15·68	14·96
	N_1	15·13	15·30	15·86	15·43
	N_2	15·44	15·34	16·78	15·85
	Mean ..	15·05	15·09	16·11	15·41

Least sig. differences for marginal means:—	1952	1953	2 Years
P=0·05	1·27	1·06	1·28
P=0·01	1·75	1·46	1.76

In 1952 the higher rate of cattle manure (C_2) increased the yield of clean coffee by 2.22 cwt. per acre (i.e. 45 per cent more than control). An appreciable increase due to cattle manure has not been recorded hitherto. At the same time increases due to N_1 and N_2 were 1.24 and 1.45 cwt. per acre respectively (i.e. 28 per cent and 33 per cent more than control). In 1953, however, yield differences showed the reverse trend, though generally of lesser degree. The heavier dressing of cattle manure led to a significant increase in crop in 1952 and to a significant decrease in 1953, but in the aggregate yields for the two years there was no improvement in yield due to the heavier dressings of either manure or nitrogen. During both years the trees were in process of conversion from single to multiple stem pruning; in 1952 the crop was borne on half the number of primaries of the original single stem and on these and the new heads in 1953. For this reason treatment effects during both years should be regarded as only conditional.

Manurial Trial—II

The treatments and conclusions from this trial, up to and including the 1952 season, were recently reported [3]. Crop yields for 1953 are tabled below with those of the previous three years:—

TABLE VIII

Summary of Four Years' Yields—in Cwt. of Clean Coffee Per Acre

Treatment		Year				Total for 4 years
		1950	1951	1952	1953	
Sulphate of ammonia	No N ..	3·04	4·46	14·48	6·07	28·05
@ 4 cwt. per acre.	+ N ..	4·63	4·53	19·13	4·59	32·88
Mean response to N:	Per cent ..	+52·3	+1·00	+32·1	−24·4	+17·2
Double Superphosphate	No P ..	4·14	4·61	17·06	5·44	31·25
@ 2 cwt. per acre.	+ P ..	3·53	4·38	16·55	5·22	29·68
Mean response to P:	Per cent ..	−14·7	−4·9	−3·0	−4·0	−5·0
Cattle Manure	No C ..	3·90	4·87	16·02	5·39	30·18
@ 14 tons per acre.	+ C ..	3·77	4·12	17·59	5·27	30·75
Mean response to C:	Per cent ..	−3·3	−15·3	+9·8	−2·2	+1·9
Least significant difference ..	P0.05 ..	0·81	1·82	3·11	2·21	2·10
	P0.01 ..	1·19	2·70	4·60	3·28	3·11

Defoliation and subsequent die-back of bearing branches is acknowledged as the most common symptom of overbearing and crop strain. Although the 1952 crop was three to four times heavier than the 1951 crop, the average number of die-back branches was three to four times greater after the 1951 crop. In fact, in spite of very heavy crop in 1952, die-back was not abnormally heavy. It is not surprising, therefore, that the trees were able to bear well again in 1953, but the effects of nitrogen on the trees in these two years requires examination. In 1952 nitrogen increased the average yield by a third and reduced die-back to 55 per cent of the rate recorded on the untreated trees. This implies that the addition of nitrogen allowed the trees to carry a heavier crop with less strain and therefore without detriment to the following crop. Nevertheless, in 1953 the yield was not greater than the untreated trees. In the aggregate of four years the mean annual response to an annual dressing of 4 cwt. of sulphate of ammonia has been an addition of about $1\frac{1}{4}$ cwt. of clean coffee to each year's crop. A trend towards a biennial response to nitrogen is also becoming established. Heavy dressings of superphosphate and cattle manure, singly and in combination, have failed to affect yields.

Mulch Trial

The design, layout and initial results of this trial have been described in previous reports and in a recent paper in the *Empire Journal of Experimental Agriculture* [3]. Conclusions derived from the first two years' results are not borne out by those in the following two years, 1952 and 1953, as shown in the following tables:—

TABLE IX

Main Effects of Applying Grass Mulch—Yields in Cwt. of Clean Coffee Per Acre

Year	1950	1951	1952	1953	Total
Rainfall	26 in.	54 in.	39 in.	28 in.	36½ in. (mean)
Control: no mulch (1)	9·76	6·81	3·16	6·34	17·07
Mulched before long rains: all rows (A) ..	1·52	12·08	2·52	7·01	23·13
Mulched before long rains: alternate rows (B)	1·09	10·58	1·61	7·43	20·71
Mulched after long rains: all rows (AB) ..	0·71	9·82	3·52	7·19	21·24
Least sig. difference — P0.05	0·33	1·14	0·96	0·86	—
P0·01	0·44	1·53	1·30	1·18	—

TABLE X

Interaction of Cattle Manure and Mulch—Yields in Cwt. of Clean Coffee Per Acre

Year	1950	1951	1952	1953	Total
Control: no mulch or manure (1) ..	0·61	6·67	2·22	6·47	15·97
Cattle manure (CM)	0·91	6·95	4·10	6·21	18·17
Mulch, pre-rains: all rows (A) ..	1·49	11·86	2·54	6·49	22·38
(A) plus (CM)	1·54	12·30	2·50	7·53	23·87
Mulch, pre-rains: alternate rows (B)	1·05	11·37	0·95	7·48	20·85
(B) plus (CM)	1·13	9·78	2·27	7·37	20·55
Mulch, post-rains: all rows (AB) ..	0·55	9·87	3·71	7·33	21·46
(AB) plus (CM)	0·86	9·11	3·32	7·05	20·34
Treatment means: without (CM) ..	0·93	9·94	2·36	6·94	5·04
With (CM)	1·11	9·54	3·05	7·04	5·18
Least significant differences:—					
within the table— P=0.05 ..	0·47	1·60	1·36	1·24	—
P=0·01 ..	0·62	2·16	1·84	1·68	—
for marginal means— P=0·05 ..	0·23	0·80	0·68	0·62	—
(CM contrasts) P=0·01 ..	0·32	1·09	0·92	0·84	—

TABLE XI

Interaction of Mulch and Nitrogen—Yields of Clean Coffee Per Acre

Year	Mulch Treatment	Nil	Nitrogen Dressing, 23 lb. of Nitrogen as:		
			Ammonium Sulphate	Sodium Nitrate	Nitrochalk
		(1)	(D)	(E)	(DE)
1951	Control: no mulch.. (1)	5·22	7·38	8·19	6·45
	Mulch, pre-rains: all rows (A)	13·45	9·63	12·73	12·50
	Mulch, pre-rains: alternate rows .. .. (B)	10·78	10·10	11·39	9·73
	Least significant difference—				
	P 0·05		2·25		
	P 0·01		3·11		
1952 Conversion year	Control .. .. (1)	3·91	2·74	3·40	2·58
	Mulch .. .. (A)	1·62	4·17	2·92	1·37
	Mulch .. .. (B)	0·73	1·60	2·96	1·16
	Least significant difference—				
	P 0·05		1·93		
	P 0·01		2·60		
1953	Control .. .. (1)	6·10	6·26	7·14	5·92
	Mulch .. .. (A)	6·96	6·39	6·88	7·88
	Mulch .. .. (B)	6·82	8·20	7·48	7·28
	Least significant difference—				
	P 0·05		1·75		
	P 0·01		2·37		
3-year total	Control .. .. (1)	15·23	16·38	18·73	14·95
	Mulch .. .. (A)	22·03	20·19	22·53	21·75
	Mulch .. .. (B)	18·33	19·90	21·83	18·17
	Total	55·59	56·47	63·09	54·87

The Production and Utilization of Mulch Grass

Of the numerous problems which arise in fulfilling a mulching programme that of producing the maximum quantity of grass is undoubtedly supreme throughout the drier East of Rift districts. By reason of its ability to produce heavy crops of grass from a short growing season Napier grass (*Pennisetum purpureum*) is widely used for the purpose. Until recent years regular manuring of mulch grass swards has rarely been practised on estates. Moreover there was little indication that the deterioration which invariably occurs after four or five years of cutting was largely due to soil impoverishment. The trials described here were intended to provide answers to the queries: can a degenerate Napier grass plantation be restored to a highly productive state by means of the addition of small annual dressings of fertilizers and/or manures? And can degeneration be prevented or alleviated by such means?

MANURIAL TRIAL I

Two replicates of a 2 × 2 × 2 design were used to test the main effects and interactions of the following treatments on grass in poor condition. The grass was planted in 1944 on former coffee land of good soil depth and gentle slope (<3 per cent); the trial commenced in April, 1951. Treatments were: (*a*) nitrogen nil and 1 cwt. per acre of sulphate of ammonia, broadcast in the interrows early in the long rains at a time when a deficiency of soil nitrogen is thought to arise; (*b*) phosphate nil and 1 cwt. per acre of soda phosphate broadcast in the interrows at the start of the long rains and later forked into the surface soil; (*c*) cattle manure nil and 10 tons per acre of good-quality manure turned into the soil in the interrows at the start of the long rains. Plot size was 40 yards by 10 yards, comprising five rows of grass with six feet between centres of rows. At harvesting the border row of each plot was discarded, leaving three 40-yard rows; two random samples of 15 ft. each were taken from each row. Samples were weighed and spread to dry. When fully sun-dry all samples were reweighed and sub-samples taken for dry matter estimate.

TABLE XII

Yield Summary—Fresh Weight of Grass in Tons Per Acre

Harvest Season	Sulphate of Ammonia		Soda Phosphate		Cattle Manure		Least sig. diff. P 0·05	Mean Sun-dry weight: tons/ acre
	1 cwt./acre		1 cwt./acre		1 cwt./acre			
	No N	N	No P	P	No C	C		
August, 1951 ..	20·78	26·00	22·18	24·60	23·13	23·65	8·83	12·08
February, 1952 ..	18·64	18·30	19·99	16·95	16·98	19·96	4·29	19·28
July, 1952	23·39	20·92	22·60	21·71	17·66	26·65	5·37	10·47
February, 1953 ..	8·15	8·98	9·19	7·94	7·96	9·17	2·40	4·42
July, 1953	15·31	14·05	15·38	13·98	13·22	16·14	5·96	5·45
5 Seasons' Totals ..	86·27	88·25	89·34	85·18	78·95	95·57	19·46	43·85

From the table it is apparent that error variance was high in all seasons and in the aggregate yield data. The only significant treatment difference was in the 1952 long rains season, when cattle manure increased yields by over 50 per cent. There appears to be a response to manure in all seasons except the first, but no other contrasts attain significance; nor does a 21 per cent difference in the total yields reach significance. In the 1952 long rains season there was a significant negative interaction between phosphate and manure; whereas manure alone doubled the yield, the addition of phosphate caused this to drop to only 55 per cent more than control.

Samples for dry-matter estimates were taken, but grinding and oven-drying could be undertaken on small samples only and these proved insufficient to give a reliable estimate of the dry-matter content of individual samples. For this reason therefore yields were calculated on the basis of fresh and sun-dry weights.

MANURIAL TRIAL II

Parallel treatments, design, plot size and sampling were used to assess the effects of applying nitrogen, phosphate and cattle manure to Napier grass at planting time and annually thereafter. The trial was sited on deep and fertile

land which had been under coffee for about 30 years prior to being uprooted in 1950. The land was then fallow for a year to allow a dense growth of couch grass to be eradicated before the trial was planted in April, 1951. Single lines of cane setts were planted horizontally in plough furrows 6 ft. apart; wherever they were to be applied manure and phosphate were placed in the furrow before the cane was planted. In subsequent years manure and phosphate were applied to interrows at the start of the rains, as in the first trial. Nitrogen was applied early in the rains to coincide with the estimated time of nitrogen deficiency in the soil. During the first year after planting soil moisture was plentiful until February, 1952; from sprouting until this time growth was almost unchecked. For this reason and in order to encourage rapid development of young plants the first cutting was deferred until after the onset of the dry season in January, 1952.

TABLE XIII

Yield Summary—Fresh Weight of Grass in Tons Per Acre

Harvest Season	Sulphate of Ammonia		Soda Phosphate		Cattle Manure		Least sig. diff. P 0·05	Mean Sun-dry weight: tons/acre
	1 cwt./acre		1 cwt./acre		10 tons/acre			
	No N	N	No P	P	No C	C		
February, 1952 ..	34·51	32·66	34·80	32·37	34·55	32·62	7·31	22·47
July, 1952	51·72	50·34	50·91	51·15	50·65	51·41	7*	21·83
February, 1953 ..	18·75	29·73	18·83	20·65	19·67	19·81	3·02	11·11
July, 1953	25·69	25·91	25·81	25·79	24·97	26·63	5*	9·34
4 Seasons' Totals ..	130·67	129·64	130·35	129·96	129·84	130·47	14·62	64·75

*Approximate value.

Yields in all four seasons were about twice those in Trial I. No treatment differences approached significance in any season or in the aggregate yields. Samples from the last harvest (July, 1953) were submitted to the E.A.A.F.R.O. laboratories for spectrographic analysis. In these an abnormally high content of potassium was found, ranging from 3 per cent to over 6 per cent of the dry matter. Since an acre of Napier grass often yields more than 10 tons of dry matter per annum it follows that an annual withdrawal of potassium from the soil at such a rate would be certain to exhaust the soil's available resources within a short period. Hence potassium is likely to become a limiting factor to Napier grass growth and the investigation necessary to ascertain the crop's requirements began in November, 1953.

The results of both these trials contrast with those reported by Pereira [4], who found that cattle manure and superphosphate each caused big increases in yield when applied to young Napier grass growing on soil of poor fertility on an eroded slope. Reasons for the contrast in response may be sought in the state of the soil and its treatment during the previous 50 years.

The Relative Persistence and Efficiency of Mulch Grasses

Three tests were conducted during 1951–53 to compare the value for mulching of six species of grass. These were:—

Napier grass (*Pennisetum purpureum*), the common strain widely distributed throughout the Kenya Highlands.

Hairless elephant grass (*Pennisetum purpureum*), a strain imported from Uganda, known as "Clone S.4", with relatively hairless leaves.

Cymbopogon validus, a common upland grass in the Kenya Highlands.

Echinochloa species, a riverine grass, similar to *E. pyramidalis*, with a purple seed head.

Hyparrhenia rufa, a common tall grass of the Scattered Tree Grassland.

Guinea grass (*Panicum maximum*), a local vigorous strain.

Evidence from the tests was insufficient to justify definite conclusions being drawn, but good indications emerged regarding the relative performance of the species tested; these are given briefly below.

First Trial—1951

The fresh weight of Napier grass needed per unit length of a standard mulch band (7 ft. wide by 4 in. deep) was about three times that of either *C. validus* or *H. rufa*. Thus the advantage of much heavier yields from Napier grass may be neutralized in full or in part at least; in this case the acreage of Napier grass required to mulch an acre of coffee was a little greater than that of *C. validus*. Mulch bands were laid on 23rd July, 1951; after six, 18 and 21 weeks the amount of *C. validus* mulch residue was heavier than the other species.

Second Trial—1952

The initial depth of mulch laid (on 29th March, 1952) was governed by the yield of single 1/40th-acre plots. Because this principle was adopted the derivable information was biased by the influence of yield. Heavy yields of both Napier and elephant grasses permitted a very thick cover of mulch, with proportionate advantages in efficiency of soil moisture conservation. That this was so was manifest in measurements of soil moisture taken in the top six inches, viz.: after 15 weeks the soil moisture content below *H. rufa* (2.89 in. mean initial depth) and Guinea grass (4.22 in. mean initial depth) was significantly less than that under Napier grass (9.58 in. mean initial depth) of elephant grass (7.53 in. mean initial depth). After 25 weeks the higher soil moisture content under these was more marked and, by this time, significantly greater than under *C. validus* (4.82 in. mean initial depth) or *Echinochloa* sp. (6.75 in. mean initial depth). After 40 weeks the weight of mulch residue was measured: at this stage elephant grass was superior to the other species.

Third Trial—1953

An approximately equal depth of mulch of five species was laid in three randomized blocks (on 28th February, 1953). Soil moisture was measured after four, 10 and 20 weeks: no consistent differences were apparent in respect of soil moisture conservation efficiency. After 30 weeks the residual weight of *C. validus* mulch was greater than Napier grass or Guinea grass.

These three trials indicate that yield trials of different species of mulch grasses should be accompanied by studies of mulch persistence and efficiency, since it is clear that yield is not the sole criterion by which a species should be judged.

Pectic Enzymes in the Fermentation of Coffee

In deference to request a series of tests was conducted at the Research Station during the picking season of 1952, commencing in July and continuing at regular intervals until the end of the year, with the object of studying

the action and effect of a synthetic pectic enzyme on bulk coffee during fermentation in tanks. A range of conditions and doses were tried and the effects were gauged mainly by the length of the fermentation process and the liquoring quality of the coffee after treatment. Details of the tests and their results were published in February, 1953 [5]. It was considered that there was no practical advantage in the use of the particular enzyme tested, for the following reasons: the fermentation process was not sufficiently hastened by the addition of economic doses of the enzyme to be of practical value and doses of enzyme failed to have any but a harmful effect on liquoring quality.

P. A. JONES,
Agricultural Officer.

References

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[3] ———— ibid., "Field Responses by Kenya Coffee to Fertilizers, Manures and Mulches", *Empire Jour. Expt. Agric.*, 1954, 22, No. 85.

[4] H. C. Pereira, *Bull. Coffee Bd. Kenya*, 1951, June, p. 132.

[5] P. A. Jones, *Bull. Coffee Bd., Kenya*, 1953, 18, p. 325.

REPORT FOR THE YEARS 1952 AND 1953 BY THE PLANT PATHOLOGIST AND PHYSIOLOGIST, COFFEE SERVICES

General

During 1952 I was absent from the laboratory from the end of April to the end of October on overseas leave and for an additional month due to illness. In consequence, apart from field trials, this report deals mainly with work carried out during 1953.

The Plant Pathologist, Mr. P. Clinton, continued to work on Coffee Berry Disease during my absence until he resigned in August. The vacancy has remained unfilled.

The following articles have been published:—

"Spraying in Time can Prevent Leaf Rust"—*East African Standard,* reprinted in the *Coffee Board Bulletin,* Vol. 17, Jan., p. 9.

"Coffee Berry Disease—A Survey of Investigations Carried Out up to 1950"—*E.A. Agricultural Journal,* Vol. 17, Jan., 1952, p. 130.

"Concentrations and Rates for Fully Mechanized 'Tonic' Spraying of Coffee"—mimeographed and distributed to the trade, April, 1953.

"Anti-Leaf-Fall Spraying in Coffee"—*Coffee Board Bulletin,* May. 1953.

Anti-Leaf-Fall Spraying

(1) Field Trials of Copper- and Non-Copper-Containing Fungicides

The field trial of copper- and non-copper-containing fungicides at the Scott Laboratories was concluded by taking the 1951/52 crop. The design is a combination of a 6 × 6 latin square and a 6-plot randomized block with individual tree plots and has run for four years. As regards leaf-fall the main conclusions are that in the first two years this was as well controlled by the sprays which did not contain copper as by those which did. In the second two years, the former continued to control leaf-fall but not to the same extent as the copper-containing sprays. This may have been due to the lower number of sprayings carried out per season, a reduction necessitated by the removal of the laboratory from the Scott Agricultural Laboratories to Ruiru.

Table No. 1 gives the yield for 1951/52 for both cherry weight and clean coffee for the various treatments and also for the cherry weights over the four years the experiment ran. The results confirm those already obtained in showing no significant response to either copper or non-copper sprays, although the four-year totals are not so variable from tree to tree that a 28.4 per cent difference could not have been detected in one experiment in a hundred. Either this is that experiment—the one in a hundred—or copper spraying has failed in this particular case, for some reason which is not at all apparent, to produce its usual response.

Table 1

Treatment	1951–52 Clean Coffee		1951–52 Cherry Weights		1948—1952 Cherry Weights		
	lb./tree	per cent control	lb./tree	per cent control	lb./tree	per cent control	lb./tree
Control	4·98	100·0	16·4	100·0	42·7	100·0	43·67
Manurial Copper	5·72	114·8	18·6	113·4	44·6	104·4	
Bordeaux	5·66	113·7	18·1	110·3	36·1	84·5	41·35
Burgundy	4·65	93·9	17·8	108·5	46·6	109·1	
Tulisan	3·73	74·9	12·6	76·8	40·1	93·7	40·96
Lime Sulphur	5·60	112·5	16·9	103·1	41·9	98·1	
Significant difference—							
5 per cent point	2·98		8·4		9·1	21·3	
1 per cent point	3·95		11·2		12·2	28·4	

(2) Field Trial of Copper Spraying at Solai

The trial is a 4 × 2 × 2 factorial with four times of spraying: nil; end of May; mid-July; and end of September. Sprays are applied at 1 and 3 pints per tree and at concentrations giving 0.13 and 0.065 oz. copper per tree. There are four blocks of eight rows of 20 trees giving two absolute replications. Details were given in the previous report. Sprayings in 1952 were given on 28th May and 29th July to the first half and a week later to the second half owing to trouble with the pump. The third spraying was not carried out due to further trouble with the pump and the declaration of a State of Emergency.

Leaf-fall

Recording of leaf-fall was commenced in 1951. The method was to choose four trees in each plot at random and to observe the leaf-fall from a single branch chosen at random on each of these trees. This was done by marking the branches for the growth produced between each recording date by tying on strings and recording the number of leaves produced since the previous recording date. The loss of the leaves from each of these regions of growth was recorded by counting the number of leaves present on them on subsequent recording dates. In 1951 and 1952 recordings were made so that the growth period (April to December) was divided into three, and in 1953 into five.

So far, the leaf-fall records have been analysed up to the end of 1952. There was a marked maximum of leaf-fall in August to September, 1951, and a smaller peak in December to January, 1952, separated from the first by a shallow depression. In 1952, in March to May, leaf-fall was very low. There was a low peak in June to July and a higher one in December to January, 1953. Leaf-fall was much less marked in 1952 than in 1951.

A number of significant results were obtained for the effect of spraying on leaf-fall rate. The picture, however, is complicated by the fact that the real factor which is being affected is the length of leaf life of a population of leaves of very differing ages and the effect of a given spray may not be the same on leaves of different ages. Further, a decrease in leaf-fall at any one time must necessarily have its counterpart in an increase at a later date.

The May spraying showed a lower leaf-fall rate than the control during the August peak. Although this was not statistically significant, the July spraying which gave slightly higher leaf-fall than the control, showed a significantly higher fall than the May spraying (5 per cent point). The lower rate associated with the May spraying persisted during the October minimum when it was significantly less than that of the control (5 per cent point). It then swung up to higher than control (non-significant) in the second maximum leaf-fall period (December-January) and then to lower than control in February-March.

The July spraying showed a non-significantly higher rate than control immediately following application. From this it swung to significantly lower in October-November. This latter may have been in part due to the higher rate just preceding and in part due to an actual control of leaf-fall.

The September spraying had no effect until the first half of the second maximum leaf-fall period when it produced a strongly significant reduction in rate over control. In the second half of the same period it swung to higher than control (non-significant).

Thus there is evidence that the May spraying reduced leaf-fall rate in the middle part of the year and that September spraying strongly reduced it at the onset of the dry weather. July spraying was least effective but appears to have possibly reduced the rate in the period before the short rains and may possibly have increased it slightly in August.

As the above results are somewhat obscure due to the reasons given, it was thought that a study of the effects on the amount of leaf on the branches might give a clearer picture. The control showed a rise to maximum foliation in July and then a gradual fall, the rate of fall decreasing in January-February once the dry weather was well established. The lowest level was reached, as might be expected, just previous to the onset of the rains in April. May spraying produced a nearly significantly higher level of foliation than control (or the other treatments) in November. September spraying produced a significantly higher level (just short of the 1 per cent point) in January-February. July spraying foliation showed little difference from control.

Owing to the method of recording, it was possible to distinguish the effects of spraying on leaves of four different age groups. These latter were as follows: Group 1: formed mainly in September to February, 1950. Group 2: formed from start of long rains up to mid-July, 1951, i.e. long rains leaf. Group 3: formed September, 1951, to February, 1952, i.e. mainly short rains leaf.

May spraying showed a decrease in leaf-fall rate over control (nearly significant) with short rains leaf of 1950 in August and a significant decrease (1 per cent point) in October-November for long rains 1951 leaves. There was little difference for Group 3 leaves, but with short rains 1951 leaf, there was a decrease over control (not quite significant) and over September spraying (5 per cent point). July spraying showed a small and non-significant increase over control in August with short rains 1950 leaves and a significant increase (5 per cent point) at the same time with long rains 1951 leaves. This is interesting as it confirms the tendency noted above and suggests that spraying at this time has an adverse effect even with relatively young leaves. There was, however, a significantly lower (5 per cent point) leaf-fall rate with the same leaf-age group in October-November. This of course may have been mainly a compensation effect due to the earlier higher level. With Group 3 leaves, a similar increased rate was observed. Short rains 1951 leaves being formed after the July spraying, were unaffected, as might be expected. September spraying showed a decrease over control with long rains 1951 leaves in December-January (5 per cent point) and again with July-September (Group 3) leaves at the same time (5 per cent point).

As regards foliation produced by the various age groups, May spraying showed a tendency to affect Groups 1 and 2 most, i.e. leaves produced in the short rains of 1950 and the long rains of 1951, but the effects fell slightly short of significance. No significant effects on foliation of any group were detected for July spraying. September spraying showed a slight but non-significant decrease in the numbers of July-September formed leaves remaining on the trees in February to April. It gave a slight but non-significant decrease in the short rains 1951 leaves present in April to June, 1952.

It is obvious from the above discussion that there must have been a number of significant effects of spraying on length of leaf life as reflected by rate of leaf-fall and foliation. It would be more satisfactory if a direct measurement of leaf life could have been undertaken but this would have been highly laborious and entailed individual and frequent recording of individual leaves, an impossibility with an experiment which was only visited about once every two months. However, from the data available, it is possible to calculate indirectly the order of the effects and as this produces a clearer picture, this has been done.

If in a population of leaves produced at the same time, their length of life is normally distributed, the time-mortality curve expressed as a percentage of the original population will be sigmoid and if the percentage mortality is transformed

to a probit scale a straight line will result. With a population of leaves produced over a relatively short period at an approximate uniform rate, the same would apply.

The probit mortality percentage to time curves have been drawn for the four age classes of leaves described above. They were found to approximate to straight lines, the main divergencies being due apparently to the slowing down of abcission which is to be expected (*see* previous annual reports) due to a growth period. This occurs mainly in the tails of the curves and does not interfere to any extent with the shape in the middle regions. The average slopes of the curves were estimated by using a planimeter. The date on which these cross the 50 per cent mortality level gives the average date by which the leaves had fallen off. From the known average date for formation of the leaves in each group, the average length of life could be obtained. The results are given in Table II:—

TABLE II

Effects of Spraying Dates on Length of Leaf Life

Group	Date leaves formed	Average life unsprayed (months)	Average date by which lost	Effect on Leaf-Life of Spraying (Weeks)		
				May	July	Sept.
1	Sept.–Jan., 1950..	9¼	Aug.–Sept., 1951	+3·8	−1·5	−1·5
2	April–July, 1951	7¾	Nov.–Dec., 1951	+3·3	+2·8	−1·2
3	Aug.–Sept., 1951	5½	Dec.–Jan., 1952..	−0·4	−1·9	+9·7
4	Oct.–Jan., 1952 ..	7	May–June, 1952	+4·1	+1·3	+0·1

The statistical significance of these figures has not been calculated as it would have involved an excessive amount of work and the results already described above may be used in assessing the significance of these differences.

Leaves produced in the short rains of 1950 were the longest lived of the classes and fell off in the period between the long rains and short rains the following year. May spraying appears to have increased their life by nearly a month, but both July and September spraying may have caused them to be shed slightly earlier. This is in agreement with the view that leaves which are becoming old may fall somewhat earlier if sprayed. The long rains leaf of 1951 fell off at the end of the year as the dry weather began. Its life was increased both by the May and July sprayings by about three weeks, but they may have been caused to fall slightly earlier by the September spraying. The leaf formed between the long and short rains, 1951, was the shortest lived of the year, falling off as the dry weather of December-January set in. Its life was markedly increased by the September spraying, which kept it on right through the dry weather. The short rains leaf of 1951 behaved much as that of the previous year, falling off after the long rains and its life being increased by about a month by the May spraying.

It may be concluded that there is fair evidence that May spraying increases the length of life of mature leaf on the tree at the time of spraying unless it is of considerable age already. July spraying has the least effect of all the sprays, but there is fair evidence that it increased the length of life of long rains leaf; it may have decreased that of the previous short rains. September spraying had the most marked effect on length of leaf life, prolonging that of the leaf formed just previous to its application by nearly two and a half months, an undoubtedly real and highly significant result. These findings agree with the opinion expressed in earlier reports that spraying is best avoided at times of natural leaf-fall, but should just precede such periods.

The above results apply to the overall effects of the sprays, whatever their concentration and rate. It is possible that there may have been some differential effects of these factors, though little evidence for this was obtained in the analyses.

Effects on Yield

The procedure employed for picking the crop and estimating the clean coffee from samples was described in the last report. The only modification has been that where a 10 per cent sample would fall below 5 lb. of cherry, a minimum of 5 lb. of cherry was taken instead. This ensured a sufficiently large sample to obtain satisfactory figures for clean coffee ratio, etc. The percentage by weight of beans above grade B size was also obtained from these samples. This was done by passing them over a "B" screen in the form of a small rotary sieve. From the percentage weights from the samples, the figures per plot for the total crop were calculated. In addition, the weight of 500 beans was obtained and similarly calculated for the whole crop from each plot.

Table III gives the yield results for cherry and Table V gives them for clean coffee over the two years, for the main treatment effects:—

TABLE III

Cherry Yields, Solai Copper Spraying Trial

Treatment	Yields (Cherry)					
	1951–52		1952–53		Av. for 2 Years	
	lb./acre	per cent control	lb./acre	per cent control	lb./acre	per cent control
Control (T_0)	7,922	100	2,216	100	5,069	100
May spraying (T_1) ..	8,999	114	6,018	272	7,508	148
July spraying (T_2) ..	8,297	105	4,212	190	6,254	123
Sept. spraying (T_3) ..	8,883	112	6,075	274	7,479	148
2 per cent at 1 pt. (C_1 D_0)	8,466	107	5,523	249	7,041	139
1 per cent at 1 pt. (C_0 D_0)	8,538	108	4,634	209	6,586	130
½ per cent at 3 pts. (C_1 D_1)	8,539	108	4,634	209	6,587	130
¼ per cent at 3 pts. (C_0 D_1)	8,559	108	3,731	168	6,099	120
Significant difference 5 per cent	920	12	1,244	57	not calculated	
Significant difference 1 per cent	1,202	15	1,737	79		

CONCLUSIONS—

1951–52: $T_1 > T_3 > T_2 > T_0$; only T_1 significantly (5 per cent) higher than T_0. ½ per cent > ¼ per cent > 1 per cent > 2 per cent; differences small and non-significant. Also significant (5 per cent) interaction of C x D x T_2 — T_3.

1952–53: $T_3 > T_1 > T_2 > T_0$. Significant differences are: $T_3 > T_2$** /T_0*** $T_1 > T_2$** /T_0*** and $T_2 > T_0$** $C_1 > C_0$* $D_0 > D_1$* 2 per cent > 1 per cent / ¾ per cent > ½ per cent, of which 2 per cent > per cent **.

For cherry weight, there was little effect of treatment in the first year following spraying, as might be expected, and this agrees with the results of spraying trials in general. Little trust can be put in the two results which showed significant differences as the analysis of variance did not show the main effects to have been significant.

In 1952/53, the effect of the high crop in the previous year was to produce a swing to a low crop where spraying was withheld, but with spraying, this was largely overcome, producing extremely high responses. Those due to May and September spraying are about equal, whereas a less but still considerable response was obtained with the July application. Significantly higher (5 per cent point) responses were obtained with the higher level of copper per tree as against the lower and with the lower rate as against the higher. The result is that 2 per cent at 1 pint per tree was the best combination and that the same amount of copper in a greater amount of spray fluid is a less efficient spray than one with the same amount of copper in less fluid, in spite of the much greater cover produced by the former. Concentration and not amount of copper per tree appears to be the important factor. This does not mean that the rate is unimportant, but from the results it may be concluded that it is less important than concentration, but that if the latter is maintained at the optimum, increasing rate may well lead to increasing response within limits.

These results were not in agreement with the accepted practices for high-volume mechanized spraying, in which higher volumes of fluid were being sprayed than in the accepted hand-spraying rates, but at lower concentrations, these being calculated on the basis of obtaining equal amounts of copper per tree. In view of this, the data from other spray trials was examined and found to agree roughly with those outlined above. The conclusions were circulated to contract spraying firms and other people interested and were published in a summarized form in the *Coffee Board Bulletin* (May, 1953). These articles also included conclusions as to the rates for different heights and densities of coffee bush growth. It was concluded that it is best to maintain concentration constant at 6.8 lb. of Perenox in 100 gal. or its equivalent, but that if rate was increased above that advised for the type of coffee, only relatively small decreases in concentration could be made. Table IV shows the advised relation of rate to type of coffee using 6.8 lb. of Perenox in 100 gal. of water and high-volume mechanized spraying.

TABLE IV

Rates (in gallons per acre) for a "tonic" spray containing 6·8 lb. of Perenox per 100 gallons

Density of Foliage	Vertical Width of Sprayed Band (*i.e.* Length of Head of Bush)			
	4 ft.	5 ft.	6 ft.	7 ft.
Dense	155	200	215	—
Fairly dense	110	145	150	200
Average	80	100	120	135
Rather thin	60	80	85	110
Thin	55	70	75	95

The results for clean coffee follow those for cherry weight closely, the main difference being that the statistically significant responses are reduced, no doubt due to the extra variation which the sampling for clean coffee introduces.

TABLE V

Clean Coffee Yields—Solai Copper Spraying Trial

Treatment	1951–52		1952–53		AVERAGE FOR 2 YEARS	
	cwt./acre	per cent control	cwt./acre	per cent control	cwt./acre	per cent control
Control (T_0)	12·1	100	3·1	100	7·6	100
May spray (T_1)	12·1	100	8·3	265	10·2	134
July spray (T_2)	11·4	94	5·8	184	8·6	113
Sept. spray (T_3) ..	12·5	103	8·9	286	10·7	141
2 per cent at 1 pt. (C_1 D_0)	11·9	98	7·7	246	9·8	129
1 per cent at 1 pt. (C_0 D_0)	11·8	97	6·6	210	9·2	121
⅔ per cent at 3 pts. (C_1 D_1)	11·9	99	6·4	206	9·2	121
⅓ per cent at 3 pts. (C_0 D_1)	12·4	103	5·4	172	8·9	117
Significant difference 5 per cent	1·3	11	2·1	68	1·3	17
Significant difference 1 per cent			2·9	94	1·8	24

CONCLUSIONS—

1951–52: $T_3 > T_1 > T_0 > T_2$. ⅓ per cent > ⅔ per cent > 2 per cent > 1 per cent. No differences significant.

1952–53: $T_3 > T_1 > T_2 > T_0$; $T_3 > T_2^{**}/T_0^{***}$, $T_1 > T_2^{*}/T_0^{***}$, $T_2 > T_0^{*}$.
$D_0 > D_1$ and $C_1 > C_0$ both non-significant.
2 per cent > 1 per cent > ⅔ per cent > ⅓ per cent; — 2 per cent > ⅓ per cent*.

For two years: $T_3 > T_1 > T_2 > T_0$; $T_3 > T_2^{**}/T_0^{***}$, $T_1 > T_2^{*}/T_0^{***}$.

The yield results agree well with those obtained for leaf-fall and it is evident that the two are closely related. This is a very encouraging result and means that in future greater trust may be put in leaf-fall results as a means of assessing "tonic" effect. The results for percentage above and below "B" grade size indicated no significant effects of treatment. There was a trend, however, for the lower-yielding treatments to produce a greater percentage of larger coffee. The 500-bean weight results showed no significant effects of treatment in 1951/52 except for a rather obscure second order interaction of concentration and rate with time of spraying. This seems to have been produced mainly by the 2/3 per cent at 3 pints application with May and September spraying being associated with a low 500-bean weight, but a relatively high one with July spraying. The meaning of this, if any, is obscure. In 1952/53, there was a significant difference between rates (5 per cent level), 3 pints producing a higher bean weight than 1 pint. This is probably associated with the higher yield of the 1-pint rate. All the other results, although not significantly different, show a trend of decreasing bean weight with increasing crop. It would appear from this that the higher yields induced by the treatments are slightly offset by a small decrease in the weight of the beans.

(3) WEAK-SPOTTING

All attempts at isolating the organism responsible have been failures. Another means of attack on the problem of the identity of the organism must be made. The first step in this has been to try and discover the origin of the spores which produce the infection. These may be either airborne or distributed by rain splashing. If the latter, they must be produced elsewhere on the coffee bush itself or close to it. If the former, a much wider field for investigation would be presented. In order to try and get some evidence on which mode of distribution applies, a coffee bush growing in the field was enclosed in May, 1953, in a small portable green-house by building the latter round it. By nipping off the apical buds of the branches at the time, it was possible to distinguish thereafter between leaves produced before and after enclosure. Water was supplied to the tree by an

irrigation ditch. At intervals, sets of branches were inoculated with washings from trees showing abundant weak-spotting. These were carried out largely when wet conditions had been occurring in the field, on the assumption that at this time the spores of the weak-spot organism would be most likely to be present. The door of the glass-house was left open except during rains, so that airborne spores would have plenty of opportunity to enter and the tree was only protected against rain splashing. In the inoculation experiments controls (inoculating with distilled water) were used and all branches were kept moist by enclosing in alkathene bags and spraying with distilled water at intervals. Up to the end of 1953, no weak-spotting whatsoever had developed on the leaves formed subsequent to enclosure, nor on any of the two sets of inoculations which had been carried out during the short rains.

Spraying Apparatus

Whilst on leave in the United Kingdom, I visited a wide selection of firms dealing with the manufacture of spraying apparatus, the emphasis being on the results outlined in the previous annual report (1951) with hand apparatus.

The "wheel-barrow" type has been further investigated and in co-operation with Pest Control Ltd., an apparatus was designed for local manufacture. The pump was imported from England and the rest made up of locally available materials. The container consisted of a cut-down 44-gallon drum and could carry up to 27 gallons of spray fluid. It was mounted on a framework of ½-in. piping and rested on a spindle carrying two small pneumatic-tyred wheels. It had two long handles behind for pushing and a single one with a crossbar for dragging in front; this was hinged so that it could be folded upwards and back to the body of the apparatus when not in use. The pump supplied two lances, each with two nozzles. A spraying team consisted of one man to push and work the pump and two men for spraying, who helped to move the apparatus by pulling when necessary. The hoses were sufficiently long to spray eight trees, four in front and four behind, at each stop.

The method was quite successful, the only difficulties encountered being due to poor manufacture of the pump. With a better pump, the apparatus should prove very useful for small acreages, or for the odd difficult area on a large estate. The cost was in the region of £45, but might be less if produced in quantity and with some modifications. This is considerably cheaper than imported models and in addition it is better adapted to local conditions than these are.

Coffee Berry Disease

This disease continued to attack Upper Kiambu coffee during 1952, although the year was relatively considerably drier with wet conditions considerably less continuous. The disease was, however, less severe in its attack. In 1953, conditions were even drier and although the level of attack was low, there was evidence that it was much wider spread and had not the same somewhat patchy distribution it had had in 1951. It was concluded that the infection was now of a more generalized and less sporadic nature, and that in the event of climatic conditions returning to those experienced in 1951, the disease would cause a much greater amount of damage. There were no reports in either year from areas outside but adjacent to Upper Kiambu, although it had been present in these areas in 1951 to a small degree and only on especially susceptible types of coffee. It would appear that whatever the mechanism may have been which caused the 1951 outbreak, it was not purely due to the exceptional climatic conditions of that year and that the disease has come to stay in the Upper Kiambu area. This favours the theory that

the causal organism is a newcomer to the area, either by direct mechanical introduction, or by means of a mutation. Certain circumstantial evidence supports the former view.

Mr. P. Clinton continued to work on the disease until he resigned in August, 1952, and his position remains vacant. However, before he left he carried out the following investigations in addition to those reported last year: —

(1) Inoculation of berries at early stages in their development. Carried out immediately after flowering had finished on 21st April, 1952. There were wounded and unwounded controls and alkathene bags were used, being removed after five days. The disease never developed sufficiently for comparison to be made between treatments.

(2) Comparison of *Colletotrichum coffeanum* var *virulans* (the Coffee Berry Disease organism) with another strain of the same fungus (known as "var B"). A series of branches on one tree was inoculated with the one and another set on another tree with the other. One case of Coffee Berry Disease was observed using "var B" and a high incidence was noted on that using the var *virulans*. In neither case did any disease develop until it also started to make an attack on uninoculated berries. A slightly higher incidence of weak-spotting was observed on "var B"-inoculated branches.

(3) The effects of a high rate of Perenox spraying using the 2 per cent equivalent rate of 62 oz. in 40 gallons. The trees and also the ground cover were saturated with spray applied by hand lances with three nozzles, each supplied at high pressure. The layout was a randomized block with four blocks of two plots each of 12 × 6 trees. Two branches on each of four trees in the centre of each block were recorded for disease at fortnightly intervals. Spraying was carried out in August. Only a very few recorded berries were attacked by the disease so that no conclusions could be drawn.

(4) Viability of conidiospores. Conidia dried on cover glasses for nil, 4, 24 and 72 hours, and then placed in van Tieghem cells to germinate. The germination percentage was very low and there was none after 24 and 72 hours' drying. This was repeated with more concentrated spore suspensions and drying for nil, 4 and 18 hours. Germination again very low and almost nil after 18 hours' drying. Further work showed very low germination rates: (*a*) using Ringers' solutions and spores from cultures (below 10 per cent), and (*b*) the same solution and naturally-occurring spores from diseased berries (less than 0.5 per cent). Thus even without drying, the spores show very low germination rates.

(5) Growth in various media. Czapek-Dox, plain agar, Brown's and various coffee berry decoctions were tried and all produced thinner, more adpressed growth with fewer spores than with the standard Prune agar. Infectivity to wounded berries was retained.

(6) The effects of temperature on inoculation of detached berries. Berries wounded, inoculated and placed in a cold chamber in which the temperature was periodically reduced below 50°F. all developed the disease, whereas similarly treated berries kept at room temperature did not. If unwounded, berries in the cold chamber did not develop disease except in one case of entry through a pedicel. On transfer of those kept at room temperature to the cold chamber, 5 out of 12 developed typical lesions. A further similar batch inoculated with mycelium instead of conidia and which had not shown symptoms after three weeks at room temperature, showed one out of five with disease lesions when transferred to the cold chamber.

(7) Copper toxicity. $\frac{1}{4}$ per cent, $\frac{1}{2}$ per cent and 1 per cent of Perenox incorporated into Prune agar showed no inhibition of the growth of *Colletotrichum coffeanum* var *virulans* below 1 per cent, although the growth rate was reduced.

(8) Thermohygrograph records were kept at three sites on Kentmere Estate. Coffee Berry Disease attacks appeared to be correlated with periods of temperature below about 53°F., but not at all with periods of high humidity.

In addition to the work carried out by Mr. Clinton and described above, the writer made an investigation of the climatic conditions of 1951 as compared to earlier years. Rainfall records from Kibubuti Estate were examined for the period 1926 to 1951. The number of hours of sunshine for each week for the nearest recording station, Kabete, were examined for the period 1931 to 1951.

There were several years which came fairly close to 1951 for lack of rainless days during the rains and a number which in quantity of rain falling were wetter. It would appear that 1951 was exceptional for the low amount of sunshine and the lack of rainless days during the first month of the long rains, i.e. late March to the end of April. As regards the later months, May to July, 1951, was not particularly sunless as compared with other years, nor particularly wet, though after a gap at the beginning of May, there was practically daily rain until the end of the month.

The peculiar early low level of sunshine following the onset of the rains would no doubt have produced abnormally cool conditions at this time, which may easily have persisted in the second half. There is thus evidence that the long rains of 1951 were characterized both by exceptionally wet and cool conditions. Other years may, however, have approached fairly closely to these.

The spraying trial carried out at Kitale in 1951 and described in the last annual report, showed no effects of the treatments applied in 1951 when statistically analysed. The treatments were repeated in 1952, but no results were obtained as none of the trees were attacked by Coffee Berry Disease.

Leaf Rust

In order to obtain some information on the behaviour of this disease in the Makuyu area, estimates of its occurrence have been made by taking leaf samples of 100 leaves at random from a group of trees in the variety trial on the station's experimental plot on North Kitito Estate and counting the numbers of leaves affected and the numbers of lesions on these. The samples were taken at monthly intervals commencing June, 1953. Infection rose to a maximum in August and then decreased to the end of the year. The intensity of attack was relatively low.

Interesting observations were made on this disease at the Coffee Research Station on the plant which was enclosed in the portable greenhouse (*see* the section on weak-spotting above). At the time of enclosure at the beginning of May, rust was fairly common on the foliage, as it was on adjacent trees. By the middle of June, an extremely heavy attack had developed on the enclosed plant and it was much more heavily rusted than the adjacent unenclosed trees. The lesions were much larger and there were more of them. The tree was growing well, more so than those outside. None of the leaves produced subsequent to enclosure was affected. None of these produced any lesions until the middle of September, when a few produced a few spots in a position on the bush where a leak from the roof produced splashes on the leaves during rain storms. Thus, although the tree was often subjected to high humidities and a very heavy inoculum was present, it was only where rain splashing occurred that the Hemileia spores could produce infection. This shows that free water must be present for Hemileia infection to take

place. In order to reduce the level of inoculum, most affected leaves were removed in mid-June. However, further lesions continued to develop on the remaining leaves which had been formed before enclosure. As no leaves formed after enclosure developed lesions except where affected by water splashing, it would appear that some infections which took place at the latest at the beginning of May, may not have produced obvious lesions until as late as November, although the normal incubation period is probably in the region of only six weeks or so, i.e. it may under certain conditions be as long as five months.

Bricky Flavour

The following conclusions were drawn from the results of the trial of various B.H.C. formulations which was described in the 1951 Annual Report (p. 80).

There is no doubt that bricky flavour is brought about by treatment with certain B.H.C. formulations. In the control samples (33 in all) from six control plots, none developed a true bricky flavour and in only two was there the slightest suspicion: this may easily have been due to contamination during grinding in preparation for liquoring. The following are the average scores over the entire trial in order of brickiness:—

Wettable Agrocide, applied 2 months before picking	13.13
YF2340, applied 1 and 2 months before picking	6.58
Wettable Agrocide, applied 1 month before picking	5.87
YF2340, applied 2 months before picking	3.98
Agrocide 7 ring dust, before rains	1.88
Agrocide 7 ring dust, after rains	1.75
Insect Powder, 3 applications	1.38
YF2340, applied 1 month before picking	0.87
Agrocide 3, applied 3 months before rains	0.75
Agrocide 3, applied after rains	0.37
Agrocide 3, 3 applications	0.25
Control	0.25
Gammalin, both 1 and 2 applications	0.0

Wettable Agrocide and YF2340 produced large numbers of bricky samples, some "foul with brickiness". YF2340 was a little less prone than Wettable Agrocide. In all localities, applications of these two materials near the picking season were less prone to produce brickiness than the earlier applications. The late application in Upper Kiambu produced no bricky samples, an observation which agrees with the other results from this area and would suggest that under the climatic conditions, etc., holding in this locality, brickiness is less likely to be produced.

Agrocide 7 ring dusting was not very prone to produce brickiness but in one picking at the Research Station it produced several very bricky samples. There was only a very slight suggestion that Agrocide 3 ring dusting might produce brickiness. Insect powder produced a few definitely bricky samples at Ruiru Mills but nowhere else. Gammalin produced no bricky samples but it was only tried in Upper Kiambu where brickiness was not well developed with any treatment. In general, it would appear that B.H.C. formulations are more prone to produce brickiness when on the trees in dry weather. This would possibly explain the lesser tendency to brickiness in Upper Kiambu where the conditions are wetter.

Growth Recording

The design of the growth recording plot was given in detail in the last annual report (1951, p. 80). It is a 2^3 factorial with two replications comparing multiple versus single-stem, watered versus unwatered, shading versus no shading, and the plots are split for cropping versus stripping. As the conversion to multiple-stem was not completed until the end of 1953, only the stripping versus no-stripping treatments were applied.

In 1952 there were short but marked growth maxima in the long rains and short rains, the latter being somewhat less marked than the former. In 1953, the pattern was very similar, with both maxima slightly higher. The effect of stripping in both years was to increase the rate by up to one-third as much again, with the maximum increase in the June–July period and the minimum towards the end of the year, when the cropping trees actually grew faster than the stripped. There was, however, no alteration in the general form of the growth curve and it must be deduced from this that the latter is due largely to direct or indirect effects of climate and not to the state of the bush due to cropping.

At the Scott Laboratories, growth recording was terminated at the end of 1951 on the old block of trees after a nine-year period. Recording of a new block was started in 1952. The trees are of the same variety (Kenya Selected "B") as in the original block. The experiment is of a simpler design to that at the Coffee Research Station and compares single- with multiple-stem and stripping versus cropping in a 2^3 layout with three replications. Until the end of 1953 only the single-stem trees were recorded as conversion to multiple-stem of the multiple-stem plots was not complete until then.

In both 1952 and 1953, the growth pattern differed considerably from that at the Coffee Research Station. The main differences are that the maxima tend to be less sharply peaked and that the short rains growth periods are more poorly marked. Growth started about mid-February and with some variation, lasted until June. Very little growth occurred for the rest of the year. The early start was no doubt due, as in the somewhat similar year for growth, 1942, to adequate moisture being stored in the soil from the heavy rain of the previous year. In 1953, the long rains growth showed a short but high maximum similar to that seen at the Coffee Research Station. Short rains growth consisted of a prolonged but poorly-marked maximum. As at the Coffee Research Station, stripping produced higher growth rates but did not materially alter the forms of the curves.

As the watered trees in the old block used for growth recording were no longer required, the opportunity was taken to wash out their root systems and compare them with those of the unwatered trees. This was carried out on trees 2 and 3 (unwatered) and 8 and 9 (watered). The topsoil under the watered trees differed little after 10 years' continuous watering from that of the unwatered trees; it did appear a little darker however and was harder when dry. The root systems did not show any very great difference, the main one being a lower amount of feeders in those watered, although feeder bearers and permanents were about equally abundant. The difference may however be due to the feeders dying in January and rotting away where the soil was wet, but not where it was dry. The washing out was done at the end of January. The surface mat of the watered trees was developed rather closer to the surface of the soil than that of the unwatered trees, but its total depth was very similar and there was thus no evidence that the trees were not feeding to the same depth. In the angle between the axial system and the surface mat, the watered trees appeared to have rather fewer permanent roots. In general, all the trees showed very well developed root systems with strong axial development to considerable depth, that of tree 9 going down 21 ft.

The systems differed from all those washed out in the past in having a fairly even though rather sparse development of roots between the axial systems and the surface mat. Usually a considerable amount of unexplored soil occurs in this region. Both droppers from the root-mat system and lateral branches from the axial system supplied this region.

In connexion with the eventual statistical analysis of the results of studies of growth rates, an examination of the frequency distribution of growth rates for individual branches summed over a period of several months was undertaken. This was done graphically by a method devised by the writer which appears to have considerable advantages over other more laborious methods especially when the number of individual observations within a sample is relatively small. In this case there were only 16. The observations are arranged in order of magnitude and a graph drawn of the growth rate of each observation in the series against the probit of the percentage of the total number of observations which have this or a lower magnitude. For example, in one set of observations, a growth of 21 mm. over a period of three months was recorded for one branch and this amount or less for seven other branches, i.e. a total of 50 per cent of the observed branches. The value of 21 was therefore graphed against the probit of 50 per cent, i.e. 5.0 and so on for each observed growth rate. If the distribution is normal, a straight line should result which passes through the average growth rate at 5.0. If the distribution is skewed, a symmetric or asymmetric curve results which is curved upwards or downwards according to the nature of the skewing. In the case in point, there was a tendency to show an upward curvature. If the growth rates were first transformed to their logarithms, a downwardly directed curve resulted, showing that this transformation is too strong, as has been shown to be frequently the case by Kleczkowski (*Ann. App. Biol.* 36, 139, 1949). He has suggested the transformation $\log (x + c)$ where x is the variable and c is constant. A series of constants were tried and by a process of repeated approximations and interpolations, a value of 56 was found to give the best overall result. A square root transformation gave almost as good a rectification. There was, however, a fair degree of variation in skewing between different trees and different seasons and as it is never very marked, it is probable that in most cases the data would be best untransformed.

Miscellaneous

A peculiar die-back occurred on a plot of coffee in the Kabete area. A portion of the trunk of a number of multiple-stem trees died in the neck region; this was followed either by the wilting and death of the head above this dead portion or, in some cases by its breaking off early. The dead region was found to be infected with a *Phomopsis* sp. which was easily isolated and obtained in culture. Numerous inoculations of trees at the Scott Laboratories were carried out, both with mycelium obtained from the cultures and with portions of dead wood from the affected region of trees with the disease. In no case did any disease symptoms develop. As the *Phomopsis* is of a type frequently isolated from coffee material and causes latent infections of leaves, it would seem probable that its occurrence on the dead portions of the trunk may have been merely secondary. The cause of the trouble remains, therefore, undetermined. No further cases have been found.

A peculiar disease of Grevillea robusta trees growing as coffee shade in Upper Kiambu was reported during 1952. The first symptoms are a darkening of the foliage on the crown and a general appearance of lack of vigour. The foliage gradually gets thinner from loss of leaf and eventually first the tips then the whole of the branches die, followed by the death of the entire tree. In the fairly early stages, a dark coloration of the bark of the trunk becomes noticeable, affecting a narrow elongated area on the trunk and eventually a deep buff gum oozes

out at places and turns a chestnut brown as it congeals. If such a tree is felled and the trunk cut open, liquid gum oozes out from the annual rings. In the younger rings, this is chrome yellow, but in the older ones it is dark blood-red. Inside the first annual ring, the wood is whitish, with some brown discoloration. Further in, it is dull pinkish-red and the medullary rays are the same colour but darker. The tissues give off a strong sourish smell like citrus attacked by stem-end rot (*Diplodia natalensis*). Healthy wood of Grevillea gives off a slightly similar odour, but is much less marked and more pleasant.

Examination of sections of the wood under the microscope shows that the wood parenchyma and the parenchymatous cells of the medullary rays were crowded with gum globules. No sign of any fungal or bacterial organism could be detected. Owing to lack of opportunity and time, no further investigation of this disease has been made.

A case of interveinal leaf-scorch was seen on a farm in the Thika area. As in past cases, it was associated with the exposure due to heavy pruning of leaves originally produced under the shade of other leaves on the tree itself and the subsequent exposure of these leaves to hot, drying winds. A subsidiary factor in this case was a lack of available soil moisture due to a shallow soil. The pruning took place in mid-September and consisted of the removal of the tops of the old heads. The scorch was mainly on sucker growth which had been rather close under the old heads.

An investigation of the solubility of the resin-like secretion which covers the young inflorescence buds of coffee was carried out with a view to removing this from buds for serial sections and thus allowing better penetration of the embedding wax. The normal solvents for resins: xylene, benzene, etc., had no solvent action on the material. Chloroform, Acetone and Methyl Cellosolve had some solvent action and Ethyl Cellosolve was the most active solvent tried. Even with this, a thin external skin from the lump of resin-like material remained undissolved, but was so thin as to disintegrate easily.

Colour photographs have been made of a number of different disease and deficiency symptoms in coffee, so that a permanent record of the various symptoms and conditions of coffee may be available. Both colour prints and transparencies have been produced.

A large batch of valuable seedlings of coffee selections from South America were imported by the Agricultural Officer. These had been grown in quarantine in the United States and were subjected to a further period of rigorous quarantine at the Coffee Research Station before they were allowed to be planted in the open. No definite disease symptoms were seen on any of these plants, but as a safety measure all specimens showing any peculiarities of growth were rigorously culled and destroyed.

R. W. RAYNER,
Plant Pathologist and Physiologist, Coffee Services.

REPORT OF THE AGRICULTURAL CHEMIST (COFFEE SERVICES) FOR THE PERIOD MAY, 1953, TO DECEMBER, 1954

Under the existing conditions of staff shortage in the laboratory, together with the reorganization of the laboratory consequent upon the change of emphasis from the physical to the chemical side of soil and plant studies, some progress has been made in the first 18-month period under review. During 1953 some delay in commencing the main research programme resulted because of the non-arrival of essential apparatus.

The initial investigation programme adopted in June, 1953, was recorded under three major headings:—

(1) Mineralization of natural soil nitrogen and added fertilizer nitrogen in mature coffee under variable conditions.

(2) Determination of indirect plant nutrient application to coffee in the form of Napier grass mulch.

(3) Chemical control of weeds in coffee.

In this report these subjects form three main headings which have been amplified where necessary to include the results of related investigations. A number of additional and unrelated investigations have been carried out in response to problems which have arisen from time to time. These are reported together in the fourth section of this report.

Soil Nitrogen and Related Studies

The major study now being undertaken is that of soil nitrogen, and its relationship to nitrogen nutrition of the coffee tree growing on Kikuyu red loam soil series (red latosol). It was at once apparent that in order to collect and analyse the greatest possible numbers of both soil and plant samples the question of sampling, handling and analytical methods would require careful consideration.

Accordingly, the initial step in the work has been to equip the laboratory adequately so that speed and accuracy could be combined, particularly in view of the limits imposed by a small staff. Whilst this was being undertaken basic studies of technique, etc., were suspended with the single exception reported here, until this reorganization was completed. Meanwhile "applied" studies involving field sampling and analysis using accepted macro techniques, were commenced with the single main purpose of obtaining data relating to the trends in the topsoil mineralization of nitrogen under natural conditions of climate and cropping. Such information is considered desirable as a broad basis upon which to construct a general outline of the relationships between climatic seasons, periods of growth, cropping and soil nitrogen conditions.

Total Soil Nitrogen

As a method of reducing the number of manipulations of soil samples in the laboratory when determining the total soil nitrogen by Kjeldahls's method, a simple comparison was carried out between determinations made on the air-dry soil sample after it had been oven dried at 100° C. for moisture determination. Nine Kikuyu red loam topsoil samples (0–6 in.) were analysed by each

technique. It would be an advantage if the residual soil from the moisture determination, necessarily made in the first instance where NO_3-N and NH_3-N determinations are performed on the fresh soil sample, could be satisfactorily used for the total N determination. The results of this comparison, expressed as means of nine replicates were:—

Total N (per cent oven-dry soil)

Air-dry soil sample (1)	0·20088	
Oven-dry soil sample	0·21953	$\frac{D}{E_D}$ =6·39; t for n =8 and p= 0·001 =5·041.
Difference	0·01865***	

The limited data available show a most interesting and significant apparent increase in the total nitrogen percentage figure for the topsoil samples which have been dried at 100° C. prior to analysis. Further experiments have to be undertaken.

Soil Nitrification in the Field

For a period covering the short rains 1953 approximately weekly soil samples were taken in the nitrogen manurial trial 3, which is a 3^2 trial with three replications. The samples were analysed for NH_3-N and NO_3-N contents. Samples were taken at two depths, 0–3 in., 3–6 in. from the following plot treatments: the control (1), 4 cwt. ammonium sulphate applied in the long rains each year (N_1LR), 4 cwt. ammonium sulphate applied in the short rains each year (N_1SR) and 4 cwt. ammonium sulphate applied as one-half in each rains period (N_1S). The three-field trial replications were sampled separately. Each sample analysed was composed of three random samplings bulked in the field. The position of sampling was around the edge of the skirt region of mature multi-stem coffee trees which corresponds to the region of fertilizer application. A total of 11 weekly samplings were made, commencing two days after the sulphate of ammonia application. To facilitate the statistical analysis and bearing in mind that comparative trends only were sought, results from these field replicates were averaged to give a single figure for each depth and treatment at each sampling. A summary of the rainfall and soil moisture data is given before the results in Table I.

Table I

Sampling Intervals

	1	2	3	4	5	6	7	8	9	10	11
Rainfall prior to each sampling time	2·37″	0·35″	1·18″	0·51″	0·23″	0·59″	nil	0·21″	nil	nil	1·09″
Mean per cent Moisture content 0–3 in.	40	31	41	40	31	30	31	27	20	20	35
Of soil samples 3–6 in. ..	40	33	40	38	33	33	32	28	26	25	35

Approximate Field Capacity moisture content—42 per cent.

Approximate Wilting Point moisture content—21 per cent.

TABLE 1

N Treatment X Soil Depth Interaction Table (Means of 11)

Sample depth	(1)	N_4S	N_4SR (ppm oven-dry soil) NO_3–N	N_4LR	Means of 44
0–3 in. ..	36·2	227·2	307·7	155·5	181·6
3–6 in. ..	26·8	211·6	192·6	154·6	146·4
Means of 22 ..	31·5	219·4	250·1	154·9	—
			NH_3–N (ppm. oven-dry soil)		Mean of 44
0–3 in. ..	13·8	140·9	605·3	25·4	196·3
3–6 in. ..	14·7	61·4	241·6	16·8	83·6
Means of 22 ..	14·2	101·1	423·4	21·1	—

L.S.D.s AND STANDARD ERRORS—

NO_3–N: N Treatments = 5 per cent = 34·6; ·1 per cent = 46·3; SE = ±17·1
NH_3–N: N Treatments = 5 per cent = 40·3; ·1 per cent = 53·9; SE = ±19·8
NO_3–N: Soil depth = 5 per cent = 24·5; ·1 per cent = 32·7; SE = ±12·1
NH_3–N: Soil depth = 5 per cent = 28·5; ·1 per cent = 38·1; SE = ±14·8
NO_3–N: Interaction (N x SD) = 5 per cent = 44·6; ·1 per cent = 59·7; SE = ±22·1
NH_3–N: Interaction (N x SD) = 5 per cent = 56·9; ·1 per cent = 76·2; SE = ±28·2

A summary of the comparative results on the basis of mean values per treatment per sampling shows:—

(1) The mean treatment NO_3-N and NH_3-N values for the whole sampling period show predictable relationships on the basis of known field treatments.

(2) There was a carry-over of NO_3-N in the topsoil from the 4 cwt. ammonium sulphate application made early in the long rains 1953. (Long rains precipitation between March–June totalled 14.7 in.) There was, however no significant carry-over of NH_3-N detected at the time of sampling from this treatment.

(3) The largest NO_3-N and NH_3-N differences (significant) between the 0–3 in. and 3–6 in. soil layers sampled in this experiment occurred on the short rains nitrogen-treated plots. The (1) and N_4LR treatments do not show significant differences with depth, and the indication from these results is that a long rains nitrogen application will leave a uniform residual NO_3-N distribution in the immediate topsoil, but that there will be a higher NH_3-N concentration in the 0–3 in. than in the 3–6 in. soil layers.

(4) The greatest differences in NO_3-N trends, detailed results of which have not been included here, were related to rainfall. Lower values in all treatments were obtained in samplings taken after the heavier rainfalls re-corded, i.e. fifth and, to a lesser degree, the sixth sampling times. At all times, however, nitrogen variations between samples at different intervals were very large. The (1) and N_4LR treatments gave peak NO_3-N values early in the sampling period, whereas the highest recorded value of NO_3-N for the N_4SR and N_4S treatments were towards the end of the sampling period when the soil moisture was decreasing and rainfall was scanty. The most important period of NO_3-N requirement of the coffee tree in order to assist recovery for the maturation of the crop and also in respect of new leaf production would logically be from the earliest time at which soil moisture is available for the tree to utilize. In fact, an early supply of nitrogen under these conditions might serve to stimulate growth. Thus,

if nitrogen applications are made in the short rains they should be applied in the early stages to produce maximum benefit.

Annual Soil Nitrification Cycle

Advantage was taken of the opportunity to carry out soil sampling in the Plant Pathologist/Physiologists' growth recording trial. The object was to obtain a general outline of the fluctuations of soil nitrate and ammonia nitrogen during a full year period and to relate the general trends, if possible, to natural climatic conditions, and actual recorded coffee tree growth on a Kikuyu red loam soil. Within the limits of the soil sample numbers which it was possible to extract and analyse the sampling undertaken was as follows. Again standard macro methods of analysis were adopted and soil samples were extracted and analysed within two hours of sampling:—

Plots.—Two field replicates each of mature multi-stem and mature single-stem coffee.

Depth of Sampling by Soil Auger.—0–3 in.; 3–6 in.; 6–12 in.; 12–18 in.; 18–24 in.

Position of Sampling.—Three feet out from the tree trunk. This approximates the edge of the skirt region and is in the zone of coffee feeding roots.

Method of Sampling.—For each single sample from each plot analysed, three individual soil samples were taken, bulked in the field, and well mixed before sub-sampling in the laboratory.

Sampling Intervals.—No fixed sampling interval was adhered to. Sampling times were dictated by the prevailing climatic conditions and the ability to deal with the samples immediately. For example, during the rainy periods weekly or half-weekly samples were usually taken, but during the hot, dry weather samples were often spaced two to three weeks apart. Sampling was commenced just prior to the long rains, 1954.

The full annual cycle has not been completed at the time of writing, neither have all the available figures been considered in detail. It is not therefore proposed to include data details here, but to indicate certain interesting trends which are apparent in the NO_3-N data only. These may be summarized in the following manner:—

(1) After the hot and arid weather of January–March, 1954, 0–3 in. samples taken prior to the first rainfall on 1st April showed high NO_3-N content. Subsequently it was deduced that this represented a peak accumulation in the immediate topsoil, which rapidly decreased over the following 14 days of wet weather. Similar peak NO_3-N values were then obtained with increasing sample depth and time. The only tenable explanation is that of substantial leaching from the 0–3 in. layer. The time interval between peaks of NO_3-N in the 0–3 in. and the 18–24 in. layers was about one month. Thus in 1954, by the end of the first half of the long rains, accumulated NO_3-N had either been leached beyond this soil depth, taken up by the tree, or lost by other mechanisms. Following the initial leaching from the various soil layers substantial fluctuations occurred which were probably related to daily rainfall, until the end of the rains in mid-June.

(2) Between the end of the long rains and the commencement of the short rains in early November, 1954, a gradual but definite and substantial increase in NO_3-N was detected in the 0–3 in. soil layer. This was apparent to a lesser degree in both the 3–6 in. and 6–12 in. soil layers. In these samples the peak values were not as high as those recorded prior to the long rains, which represented the accumulation during the dry months of January–March.

(3) The increase of NO_3-N over the dry months in the three upper soil layers might possibly be attributed to the upward movement of soil moisture carrying nitrates from deeper down in the profile. (In a subsequent section of this report data are presented which demonstrate the accumulation of NO_3-N at depth.) But, if this were so, and if such a process was continuous after commencement, and between periods, then one might expect some indication of a reversal of quantitative soil nitrate distribution to show in the comparative trends with time interval, samples and soil depth, i.e. higher NO_3-N values appearing in soil layers from deep to shallow with time. Such information is not apparent in the data here discussed. Unfortunately, no determination has been made of some other ion, such as chloride, to serve as a check on the movement of soil moisture.

(4) One further observation can be drawn from the NO_3-N data and that is that over the experimental period recorded NO_3-N soil values are greater under the mature multi-stem than under the single-stem coffee trees. This work continues.

Vertical Distribution of Nitrogen in Kikuyu Red Loam Coffee Soils

Wherever profile pits have been dug or deep soil samples taken on the Kikuyu red loam coffee soils at this station, the opportunity to examine profile samples for NO_3-N and NH_3-N has been taken. Records exist within the Department which show accumulations, often substantial, of nitrate at considerable depth under mature coffee. Evidence of the leaching of natural nitrates down the soil profile has been found in the previous investigation; under conditions of artificial nitrogen fertilizer application loss of added N will surely occur to a lesser or greater degree depending on the rainfall and condition of the coffee following the application. The pertinent question is what degree of utilization can the coffee tree effect from these accumulations?

Table II

Examples of NO_3-N and NH_3-N in K.R.L. Coffee Soil Profiles (Shallow)

Depth	Profile R.II		Depth	Profile R.III		Depth	Profile R.IV	
	NO_3-N	NH_3-N		NO_3-N	NH_3-N		NO_3-N	NH_3-N
0–4 in. ..	5·5	8·2	0–6 in. ..	7·6	8·3	0–9 in. ..	2·6	4·1
4–16 in. ..	6·7	7·3	6–15 in. ..	6·8	7·6	9–27 in. ..	2·2	5·4
16–28 in. ..	5·4	17·3	15–30 in. ..	7·2	7·2	27–47 in. ..	5·3	3·2
28–40 in. ..	13·6	3·4	30–36 in. ..	50·2	7·8	47–68 in. ..	39·8	5·6
40–52 in. ..	21·4	2·9	36–48 in. ..	64·4	8·2	68–86 in. ..	33·8	5·3
52–64 in. ..	16·8	4·8	49–61 in. ..	39·5	7·9	Hard Sheet Murram		
64–76 in. ..	7·6	26·6	Decomposing	30·0	4·6			
Decomposing Parent Rock (8 in.) (Trachytic tuff)	3·6	4·3	Parent Rock (6 in.) (Trachytic tuff)					

*Results expressed as p.p.m. oven dry soil.

The particular profile examples in Table II are not typical of the deep Kikuyu red loam coffee soils, and were in fact examined as part of an estate soil depth survey. The samples for analysis were taken in September, 1954, immediately the profiles were exposed. The accumulations of NO_3-N noted would have occurred as a result of rainfall during April–mid-June, 1954, with, of course, the residual accumulations of previous seasons. The point of accumulation varies with total profile depth and internal drainage characteristics. With profile depths of 15 ft. and more of soil the major zone of accumulation has been found to occur at between 7–9 ft., which is well within the coffee root range. Observations of this nature will continue.

Effect of Ammonium Sulphate and Other Fertilizers on the Soil pH Value

The recommended ammonium sulphate application to mature coffee is 2–4 cwt. per acre per annum in east of the Rift Valley coffee areas and this rate of aplication is based on station experiment results with coffee produced on the Kikuyu red loam soil type. The fertilizer is applied and may often be lightly forked into the topsoil in a circle around the tree in the skirt region, i.e. 2–3 ft. from the trunk of the coffee tree. This investigation was concerned with determining the effect of regular annual dressings made to mature coffee over a number of years on the soil pH values. Topsoil samples were taken from some of the nitrogen Manurial Trial III plots which have been treated annually with 4 cwt. of ammonium sulphate per acre since 1952. Between 1947–1951 the same plots received 2 cwt. of ammonium sulphate per acre. Samples were collected in June, 1954.

Coffee in Sample Areas.—Mature multi-stem; 10 ft. by 10 ft. spacing.

Treatments Samples.—(*a*) No fertilizer application (1); (*b*) 4 cwt. of ammonium sulphate applied in the long rains (N_4L.R.); (*c*) 4 cwt. of ammonium sulphate applied in the short rains (N_4S.R.); (*d*) 4 cwt. of ammonium sulphate applied as 2 cwt. in each of the two rains (N_4S).

Position of Samples.—Samples were collected at horizontal intervals along the diagonal within a square of four trees, from a tree to the centre of the diagonal only. The sampling points were 6 in., 12 in., 18 in., 24 in., 30 in., 36 in., 48 in., 72 in. and 84 in.

Replicates.—Two field trial replicates were sampled and examined separately. A single 0–6 in. topsoil sample was taken at any one position. The pH determinations were made with a glass electrode pH meter. Replicated analyses of a bulk soil sample gave a standard deviation of $\pm$ 0.003 of a pH unit. The results for the first set of samples were given in Table III.

Table III

pH Determination (1 : 5 *air dry soil* : *water ratio*)
(*a*) *Treatment Values* (*Means of* 20)

(1)	N_4S ..	N_4SR	N_4LR	SE = +0·14
6·27	5·86	6·09	5·90	LSD = 5% = 0·29 1% = 0·40

Apart from the effect of the fertilizer on the topsoil pH value as determined in this experiment, a consideration of the shape of the graphs in Figure 1 does suggest that ammonium sulphate fertilizer should be applied to cover as large a surface area within the surface root area as possible, if excessive reductions in the topsoil pH value is to be avoided. The depression of the pH value by ammonium sulphate in the limited area of application is very marked.

A similar set of samples was taken from Manurial Trial II (2^3N x P x Cattle Manure) in which the quantitative treatments are ammonium sulphate 4 cwt. per acre, double superphosphate at 2 cwt. per acre and cattle manure at four *debbies* per tree. Only one of the treatment combinations (N × P) was sampled in addition to the single factor treatments. Two absolute field replicates were sampled and examined separately. The manurial treatments have been applied since 1950. The results are given in Table IV.

TABLE IV

pH Determination (1 : 5 *air dry soil* : *water ratio*)
(*a*) *Treatment Values* (*Means of* 20)

(1)	N	P	C	N×P	SE = +0·12
6·75	6·09	6·49	7·02	6·12	LSD = 5% = 0·24; 1% = 0·32

The N.P. and N × P treatment pH means are significantly lower than the (1) mean in the topsoil of this experimental area, whereas the C treatment has raised the topsoil pH value significantly. The previous remark made concerning the position of the ammonium sulphate application applied to the double superphosphate fertilizer in a lesser degree.

The decrease of the topsoil pH value with ammonium sulphate and double superphosphate fertilizers may be the result of exchangeable bases moving down the soil profile. An attempt to determine to what extent this occurred was made by taking further samples from this same manurial trial in July, 1954. Samples were taken at four depth intervals and at four horizontal distances along the diagonal which were decided after consideration of the previous results. It was necessary to reduce the number of horizontal sampling positions in order to reduce the number of samples to be dealt with.

Horizontal Sampling Distance from Tree.—12 in., 24 in., 36 in., 72 in.

Vertical Depth Intervals.—0–6 in., 6–12 in., 12–18 in., 18–24 in.

Greater contrast in the final results might have been obtained by some variation of the sampling depth in the topsoil layers, but practical considerations of sampling technique did not appear to justify this step at the time. Only the single factor treatment plots were sampled.

TABLE V

pH Determination (1 : 5, *air dry soil* : *water ratio*)
Treatment X Depth Interaction Table (*Means of* 8)

Soil Depth	Treatments				Means of 32
	(1)	N	P	C	
0–6 in.	6·68	6·27	6·12	6·94	6·50
6–12 in.	6·27	6·53	5·64	5·98	6·11
12–18 in.	5·92	6·09	5·53	5·75	5·80
18–24 in.	5·89	5·93	5·89	5·62	5·83
Means of 32	6·19	6·21	5·79	6·07	—

L.S.D.'s AND STANDARD ERRORS—

Manurial Treatments and soil depth intervals: 5 per cent = 0·16, 1 per cent = 0·21; SE = ±0·08.
Interaction (MT x SD): 5 per cent = 0·32; 1 per cent = 0·42; SE = ±0·16.

From these results it will be noted that the soil samples taken from the ammonium sulphate-treated plots have a significantly lower pH value in the top 6 in. of soil, but that the soil at 6–12 in., shows a rise in pH, though this is not significant in this instance. However, since the pH value is known

to decrease down the profile in this soil, and does so with the other treatments in this particular investigation it is reasonable to suggest that exchangeable soil bases have accumulated in this layer after displacement by the ammonium ion on the exchange surface of the soil colloids. In the case of double superphosphate fertilizer the effect is greater, and a significant decrease in the pH values, when compared with the (1) treatments, is noted down to the 12–18 in. soil layer. There is, however, no increase in the pH value of the layer immediately below 18 in. as might be anticipated if the evidence is interpreted in the same manner as for the ammonium sulphate-treated soil.

The reaction of the double superphosphate fertilizer will, however, be different from that of the ammonium sulphate, where one can picture the sequence of ammonium ion adsorption displacement of bases, followed by oxidation and the formation of acids; with the double superphosphate the increased acidity might be the result of free hydrogen ions. (*N.B.*—The pH value of the double superphosphate fertilizer, at a 1 : 5 fertilizer : water ratio, was 2.60.)

A general consideration of all these pH values shows that they are higher, i.e. the soil appears to be much nearer the neutral value of pH 7.0 than might be expected for this soil type. It is possible that the wide ratio of soil : water used in these determinations will account for this. However, a 1 : 2.5 ratio did not reduce the values very substantially. The soil paste method, where the soil moisture content is closer to the conditions in the field, was examined, but care was necessary when using a normal thin-walled glass electrode, and it was apparent that for routine purposes a special probe-type glass electrode would be necessary.

It was suggested by Drs. Muir and Green of Rothamsted Experimental Station during a discussion of these results that the M/100 $CaCl_2$ reagent, with which Dr. Schofield has been working, might give more reproducible results in the presence of fertilizer salts in the soil sample, and that it would also give lower relative pH values. Accordingly, a number of determinations were made using this reagent at the same soil : reagent ratio as for the previous determinations, namely 1 : 5 air-dry soil : M/100$CaCl_2$.

To obtain some idea of the differences in the pH values recorded between the 1 : 5 soil : water ratio and the soil paste methods, Table VI shows some results of a comparison between the methods for six topsoil samples (Kikuyu red loam soil type) : —

TABLE VI

(*A.O.A.C. Methods*, 1950)

Sample	1 : 5 ratio	Soil Paste
1	6·67	5·76
2	7·30	6·36
3	6·32	5·53
4	6·64	5·81
5	5·79	5·06
Mean Value ..	6·67	5·82

Difference = 0·85.

(Each value is mean of 2 replicate determinations).

A similar comparison was made between the soil paste and the 1:5 soil: M/100 $CaCl_2$ methods. Nine topsoil and nine subsoil samples (Kikuyu red loam soil) gave mean values for the soil paste method = 5.55; M/100 $CaCl_2$ method = 5.34; SE = ±0.06, L.S.D., 1% = 0.18. There was no significant (or apparent) interaction of pH method with topsoil as opposed to subsoil samples.

The soil samples which were taken in Manurial Trial II (2^3 N × P × cattle manure experiment) were re-examined using the M/100 $CaCl_2$ reagent in place of the water. The results with this method are given in Table VII and compare with results in Table V.

TABLE VII

pH Determination (1 : 5 *air dry soil* : *M*/100 *CaCl*$_2$ *ratio*)
Treatment X Soil Depth Interaction Table (*Means of* 8)

Soil depth	(1)	N	P	C	Means of 32 ±0·074
0–6 in.	5·64	5·39	5·19	5·92	5·53
6–12 in.	5·16	5·56	4·83	5·14	5·17
12–18 in.	4·93	5·12	4·83	4·96	4·96
18–24 in.	4·94	5·12	5·18	4·96	5·05
Means of 32 ±0·074 ..	5·17	5·30	5·01	5·24	—

L.S.D. (Direct effects) 5 per cent = 0·15; 1 per cent = 0·20.
L.S.D. (Interaction effects) 5 per cent = 0·30; 1 per cent = 0·40.
SE for figures for the body of the table = ±0·15.

The mean pH values found by the M/100 $CaCl_2$ method are lower but similar significant trends and differences are apparent.

Soil Organic Carbon

An important aspect of the nitrogen studies is the relationship of organic mulches and soil organic carbon to the mineralization of soil nitrogen. In the dry coffee farming areas situated east of the Rift Valley, mulching with Napier grass, or any other available vegetative material, e.g. vlei grasses, straw, is strongly recommended because of its value for raising the yields of clean coffee.

Some preliminary comparisons have been made between the well-known Walkley-Black and the Tinsley modified wet oxidation methods of soil organic carbon determination with the Kikuyu red loam soils. (Tinsley, 1950 (Method II), Trans. 4th Internat. Cong. Soil Sci. 1, 161.) The former method requires the use of a factor in the calculation of the total soil organic carbon content which may introduce an error unless the true value of this factor is known for the particular soil type under consideration. Tinsley, however, reported direct determinations giving 98 per cent recovery of soil organic carbon after three hours' boiling under a cold finger condenser.

A topsoil sample (0–6 in.) and a subsoil sample (7–8 ft.) of a Kikuyu dark red loam soil profile were each analysed by the two methods. There were five replicates of each method. The corrected Walkley-Black organic carbon values were calculated using the generally accepted factor based on 77 per cent recovery. Unfortunately it was not possible to perform any combustion train analyses as a true basis for comparison.

The corrected Walkley-Black figure was significantly higher than the Tinsley II value for the topsoil and the mean topsoil figure for the Walkley-Black method

(uncorrected) was 80.3 per cent of the Tinsley II value, whereas the mean subsoil value was only 58.7 per cent.

In a second experiment five samples of Kikuyu red loam topsoil (0–6 in.) and five samples of Kikuyu dark red loam subsoil (30–36 in.) were analysed for organic carbon content by the two methods.

TABLE VIII

Soil Organic Carbon (mgms./gm. oven dry soil)
Method X Soil Type Interaction Table (Means of 5)

Soil Sample	W–B (uncorrected)	Tinsley II	Mean (of 30) ±0·31
Topsoil	24·93	31·93	28·43
Subsoil	7·37	10·70	9·04
Mean (of 30) ±0·31	16·15	21·32	—

L.S.D. (Direct effects) 5 per cent=0·62; 1 per cent=0·83.
L.S.D. (Interaction effects) 5 per cent=0·89; 1 per cent=1·19.
SE (Interaction effects)=±0·44.

From these mean figures it will be noted that the Walkley-Black value for the topsoil samples is 78.1 per cent of the Tinsley II topsoil value, and that the Walkley-Black sub-soil value is only 68.8 per cent of the Tinsley II subsoil value. It would seem that with the topsoil samples of Kikuyu red loam soils the use of a factor of 77 per cent organic carbon recovery by the Walkley-Black method is reasonably accurate for routine purposes on the assumption that the Tinsley II method gives 98–100 per cent recovery of organic carbon.

From the very limited data of this experiment the regression coefficients and regression equations were calculated as follows:—

If x=Walkley-Black (uncorrected) data and y=the Tinsley II data, expressed as mgms. organic carbon/gm. oven-dry soil, then—

(*a*) Topsoil: regression coefficient of x on y; $dx=0.67dy^{+}$ regression coefficient of y on x; $dy=1.31\ dx^{+}$

and $x=0.67y+3.54$
and $y=1.31x-0.73$
+=significant at the 2 per cent level.

(*b*) Subsoil: regression coefficient of x on y; $dx=-0.70dy^{+}$ regression coefficient of y on x; $dy=-0.46dx^{+}$

and $x=14.85-0.70y$
and $y=14.01-0.46x$
+=significant at the 5 per cent level.

The relationship between the two analytical methods is highly correlated, as determnied by the regression analysis, for the topsoil samples and a good correlation exists between the subsoil samples although the range of organic carbon was rather small. Further work will be carried out, but in the meantime it is proposed to adopt the Tinsley II method for routine determinations.

A Chemical Study of Termite Soils in Coffee

It is a recommended practice to mulch coffee before the rains in climatic areas which are subject to periods of drought. The Napier grass or other vegetative material such as mixed vlei grasses, Rhodes grass, used in this way is readily attacked by a non-mound-building termite (*Odontotermes badius*) which

greatly accelerates the deterioration in effectiveness of the mulch. On the other hand, the value of the termites' burrowing activities is fully appreciated on the Kikuyu red loam coffee soils.

There are several pros and cons to be considered in an overall estimation of the value or otherwise of the presence of these termites in mulched coffee. Among these is the question of "Where does the soil come from which the termites use to construct their covered pathways when working among the mulch on the soil surface, or when cleaning the dead bark from mature coffee trees? Is it acid, base unsaturated subsoil which it is not desirable to mix with the rich topsoil?" The addition of acid subsoil to the rich surface coffee soil by termite activity would not be considered as one of the advantages of their activity in coffee areas.

During September, 1954, samples of termite soil were collected from widely scattered coffee fields on the station by scraping the outside of Napier grass stalks in residual mulches which had been applied to the coffee before the long rains 1954. For each sample of termite soil single 0–6 in. topsoil and 18–24 in. subsoil samples were collected in the immediate vicinity. The samples were all from areas of deep Kikuyu red loam soil. It was considered unlikely that the termite transported its building soil from any very great horizontal distance away from the Napier grass on the surface, but it was recognized that if subsoil had been used it might very well have been brought to the surface from far greater depths than 24 in. It was considered that a comparison of some chemical characteristics of the samples in the light of the known general distribution pattern of chemical values down the Kikuyu red loam soil profile would point to the most probable source of origin of the termite soils.

The following chemical analyses and other comparisons were made: (1) Comparative colour of termite soil sample, topsoil sample and subsoil sample. (2) pH values. (3) Total base exchange capacity. (4) Total exchangeable bases, exchangeable calcium and magnesium. Organic carbon values were not determined. The samples were all air dried, and after picking out the obvious organic debris from the termite soil samples, were ground to pass a 2 mm. round-hole sieve.

(1) *Colour.*—Although it was found impossible to describe related termite soil, topsoil and subsoil samples accurately with the Munsell Soil Colour Chart, it was apparent in all cases that comparitively the termite soils were lighter in colour than either the related, red, topsoil or the subsoil soils. The trend was towards a more buff colour dilution giving an altogether paler effect.

(2) *pH Values.*—The pH was determined with a glass electrode pH meter on the soil paste mixture (A.O.A.C. official methods, 1950) in duplicate.

TABLE IX

pH values (soil paste method)

Mean of 12 Samples of Each Soil			
Termite Soil	Topsoil	Subsoil	SE = +0·07
5·89	5·62	5·52	LSD = 5% = 0·15 0·1% = 0·27

The topsoil and subsoil pH values showed very little difference for samples taken from some of the sampling sites, but the termite soil samples showed a very significantly higher mean pH value or lower degree of

acidity. In every single recorded comparison of 12 termite soils, with 12 topsoils and 12 subsoils, only two cases were found where the termite soil pH value was lower than either the related topsoil or subsoil sample.

(3) *Total Base Exchange Capacity*.—Total base exchange capacity values decrease with depth in the Kikuyu red loam soils as, for example, in this profile: 0–6 in.=16.25 meq/100 gms. air-dry soil; 18–24 in.=11.55 meq/100 gms. air-dry soil; and 7–8 ft.=10.25 meq/100 gms. air-dry soil. The moisture content of these samples when air dry was 3.5–4.0 per cent on an oven-dry weight basis. Because of the obvious differences between related samples individual sample results are recorded here. The rapid copper acetate method was used, and samples were analysed in duplicate.

TABLE X

Total Base Exchange Capacity. (meq/100 gms. air dry soil)

Soil Reference	Termite Soil	Topsoil	Subsoil
A1	20·25	20·35	14·00
B1	17·50	21·65	16·75
C1	18·24	19·25	12·75
D1	13·35	16·25	12·95
E1	18·75	18·75	12·50
F1	19·75	19·75	13·35
A2	16·25	19·25	11·75
B2	15·55	19·25	12·75
C2	21·25	18·85	11·50
D2	18·24	20·85	13·50
E2	15·25	13·35	13·35
F2	15·35	19·25	14·25
Mean	17·48	18·90	13·28

SE=±0·86; L.S.D. 5 per cent=1·78; 0·1 per cent=3·26.

The mean comparison of these 12 random samples shows a highly significant decrease in total base exchange capacity for the subsoil samples, but no significant difference has been found between the termite soil and topsoil means. This probably reflects a chance preponderance, in these 12 random samples, of termite soils with values close to the corresponding topsoil figure and does not necessarily mean that the termite soils and topsoils are the same. A careful scrutiny of the three figures for any one soil reference shows that in some cases the termite soil figure is much closer to the subsoil than the topsoil value. This might indicate that the particular termite soil originated from a soil layer below the 0–6 in. topsoil and either above or below the 18–24 in. subsoil layer, depending on whether the value is greater or smaller than the latter. As there are no termite soil values which are lower than the related subsoil value it might be argued that none of the termite soils were transported from below the 18–24 in. subsoil layer, but such an argument does not take into consideration the question of a colloidally active organic matter addition to the soil by the termites.

(4) *Total Exchangeable Bases*: *Exchangeable Calcium and Magnesium*. —These determinations were made after rapid extraction with neutral normal ammonium acetate (centrifuge method). The exchangable bases were determined by the A.O.A.C. official method (1950). The calcium, and magnesium

by difference, were determined by the volumetric versenate direct titration method. The values obtained for magnesium are slightly high but none the less comparable because of this (*see J. A.O.A.C.*, 1954, 37, 966).

TABLE XI

Total Exchangeable Bases, Exchangeable Calcium and Magnesium (meq/100 gms. air dry soil. Means of 6)

	Termite Soil	Topsoil	Subsoil	S.E.	L.S.D.
Total Exchangeable bases	14·53	16·77	11·95	±1·20	5%=2·72
Exchangeable Calcium	9·23	8·87	6·13	±0·64	5%=1·39
Exchangeable Magnesium	4·88	4·34	3·19	±0·27	5%=0·60

There were no significant differences between the topsoil and termite soil figures, but the subsoil figures were significantly less in every case. There is a very noticeable trend in the mean differences between termite soil and topsoil, for whilst the mean total exchangeable base content is less in the termite soil than in the topsoil samples, the mean exchangeable calcium and exchangeable magnesium values are both greater. This agrees with the pH values recorded previously.

If the exchangeable calcium, exchangeable magnesium and exchangeable calcium + magnesium results are expressed as a percentage of the total exchangeable bases the result is truly indicative of a substantial difference between these samples.

TABLE XII

Exchangeable Calcium, Magnesium and Calcium and Magnesium Expressed as a Percentage of the Total Exchangeable Bases (Means of 6)

	Termite Soil	Topsoil	Subsoil	S.E.	L.S.D.
Exchangeable Calcium	63·9	50·6	50·9	—	—
Exchangeable Magnesium	29·5	25·3	26·5	—	—
Exchangeable Ca+Mg.	93·5	75·9	77·3	±6·1	5%=13·6

Expressed in this way a far higher percentage of the exchangeable bases consist of calcium + magnesium in the termite soil than in either the topsoil or subsoil. Clearly, the termites in working the soil incorporate additional quantities of calcium and magnesium derived perhaps from the digestion of organic plant debris.

Summarizing the results we can answer the question posed by saying: (1) that the termite soils examined were not base unsaturated; (2) that these particular samples did not seem to come from a very great depth in the soil profile; and (3) that these termite soils were less acid than the corresponding topsoil (0–6 in.), they could be differentiated by their colour from the corresponding topsoil and subsoil samples, although they were not the same colour between themselves.

Napier Grass Studies

The use of Napier grass (*Pennisetum purpureum*) as a mulch material in coffee has a very substantial proven value in terms of increased coffee in the bag. Its suitability as a mulch rests on the high yield of dry matter per acre which can be produced and its resistance to rapid and total decomposition after application.

Manurial experiments to study the value of nutrient applications for increasing dry-matter yield have been and are being carried out at the Coffee Research Station and are reported elsewhere. Apart from nitrogen fertilizer, no other fertilizers (or cattle manure) tested to date have economically increased coffee yields on the Kikuyu red loam soils and plant nutrients are applied to most coffee areas as the result of the mulch breakdown and final incorporation in the soil. It is a far better practical policy therefore to increase the production of mulch, and thereby coffee, through fertilizer and cattle manure application to the mulch crop, particularly as these plant nutrients will eventually find their way into the coffee land.

The work reported in this section has been concerned with an appraisal of the quantitative nutrient composition of Napier grass, and the indirect addition of mineral nutrients to coffee.

Mineral Analyses of Potential Mulch Grasses

An early comparison was carried out by Jones and Pereira between six mulch grass species on the basis of mulch persistency and effectiveness measured in terms of soil moisture status.

Samples of these mulch species were submitted to E.A.A.F.R.O. for spectrographic analysis and the results are given in Table XIII:—

Table XIII

Base Content of Mulch Grass Species

Grass Species	Calcium		Magnesium		Manganese		Potassium	
	%	lb.	%	lb.	%	lb.	%	lb.
Napier Grass (Common)	0·074	16·6	0·068	15·2	0·008	1·79	2·11	472·6
Napier Grass (Hairless)	0·062	13·9	0·180	40·3	0·016	3·58	2·70	604·8
Panicum maximum	0·104	23·3	0·270	60·5	0·013	2·91	1·86	436·6
Cymbopogon sp.	0·052	11·7	0·160	35·8	0·036	8·06	1·60	358·4
Echinochloa pyramidalis	0·108	24·2	0·210	47·0	0·009	2·02	1·49	333·8
Hyparrhenia rufa	0·092	20·6	0·130	29·1	0·012	2·69	1·11	248·6

Notes—

1. Data expressed as percentage of dry material.
2. The figures in pounds are the calculated additions of an element to coffee when the sun dried grass is applied as an alternate inter-row mulch. (Approximately 10 tons dry matter per acre.)

The composition of the different species varies greatly, but an interesting feature is the high potassium content of the two Napier grass strains. This high content of potassium in Napier grass mulch has been confirmed in later analyses of samples from the manurial trials. The data in Table XIV for example refer to samples taken from the old Napier grass trial cut after the long rains, 1953.

Table XIV

Per cent K in Napier Grass Dry Matter

Manurial Treatment	(1)	N	P	C	NP	NC	PC	NPC
Per cent K ..	3·97	3·23	3·78	3·74	4·60	4·14	4·72	5·15

N = 1 cwt./acre ammonium sulphate.
P = 1 cwt./acre sodaphosphate.
C = 16 tons/acre cattle manure.

The manurial treatments, particularly the two- and three-factor combinations, have raised the potassium content of the dry matter.

A General Comparison Between Plant Nutrients Removed in a Napier Grass Crop, Plant Nutrients Applied to Coffee in a Napier Grass Mulch and Plants Nutrients Removed in a Coffee Crop

The yield of Napier grass dry matter, and its mineral composition appears to vary with the age of the planting and with the physiological age when cut. Within limits imposed by the first condition, good long rains will produce a well-matured and heavy crop, whereas the short rains as in 1954 will hasten premature maturation, or may lead to the stultification of the early growth. It is therefore of little value to quote rigid mineral analyses figures, yields of dry matter and qualities of plant nutrients removed per ton of dry matter yield as such figures will be subject to very wide variations. However, an example is given of one such relationship compiled from Napier grass data in an average year. This data refers to a long rains plus a short rains crop.

The coffee cherry analyses quoted were not carried out by this laboratory, but have been abstracted from "Soil Conditions Affecting Coffee in Kenya", by D. S. Gracie and A. de L. Poer Trench (Kenya Department of Agriculture publication, 1931).

Table XV

Relationship between the Annual Removal of some Plant Nutrients in Napier Grass, the Quantitative, Indirect Application to Mature Coffee in a Stanadrd Mulch, and the Removal of Nutrients in Ripe Coffee Cherry

Factors	Plant Nutrients Content of Napier Grass		Plant Nutrients Contained in a Standard† Coffee Mulch		Plant Nutrients Removed in Coffee cherry‡
	(*lb./acre/annum*)		(*lb./acre/annum*)		(*lb./acre/annum*)
	A	B		A	
Dry Matter Yield ..	9·3*	12·4*	—	—	—
N	—	135·3	—	109·1	55·4
P	—	23·2	—	18·7	2·5
K	865·9	1483·8	934·1	1196·6	139·3
Ca	12·5	22·2	13·4	17·9	7·5
Mg	18·7	36·1	20·2	29·1	—
Mn	0·83	1·58	0·90	1·30	1·38

Notes—

A. Data from old Napier grass manurial trial (10 years).

B. Data from new Napier grass manurial trial (2–3 years).

*Yields expressed as tons dry matter per acre per annum.

†Standard mulch taken as 10 tons dry matter per acre per annum. This is an alternate row mulch, 6 in. deep settling to 4 in., put down as a 6 ft. wide swathe in 9 by 9 ft. coffee.

‡Average yield of 30 cwt. per acre of cherry taken. Assuming a 1 : 6 clean coffee : cherry ratio this corresponds to a yield of 5 cwt./acre of clean coffee.

The points of notable interest are (*a*) the large quantities of plant nutrients which are removed from the soil on which the Napier grass is grown and particularly postassium, (*b*) the large quantities of plant nutrients applied to the coffee, indirectly, in the mulch, and (*c*) the relatively small quanities of plant nutrients removed in the coffee crop. The exception here is manganese.

The Influence of Potassium on Napier Grass Yield of Dry Matter and Plant Nutrients

An obvious consideration that arises from these figures is that quantitatively the potassium balance is being shifted substantially away from the Napier grass production areas, to the coffee-producing areas. The Kikuyu red loam coffee soil is chemically well supplied with available potassium under average conditions of cropping. Further, it is possible that the accumulation of these heavy potassium additions in the coffee topsoil may exert a depressing effect on the uptake by the coffee, of calcium and magnesium.

When first it was noted that Napier grass crops removed these substantial qualities of potassium it was postulated that after a few years' cropping a Napier grass planting might very well respond to potassium fertilizer dressings. The plots of a 2^3 N × P × Cattle Manure trial were split for the application of 1 cwt. of muriate of potash fertilizer at the rate of 1 cwt. per acre. The Napier grass was about four years old at the time when this fertilizer was applied. In addition to dry-matter yields, the yield of some of the plant nutrients in the grass crop were calculated, and the effect of the treatments on the results was determined.

The yield results of dry matter and certain plant nutrients for the long rains 1954 Napier grass trial are given here. The soil in the trial plots is not typical of the eroded steep and shallow phase Kikuyu red loam soil upon which Napier grass is usually grown for mulch, but is more nearly a deep red coffee soil. This probably accounts to some extent for the limited responses obtained to the treatments, and particularly to phosphorus.

Mean yields of dry matter and the significant yield effects are given in Table XVI. The plant nutrient yields are presented in Table XVII.

Table XVI

Napier Grass Trial II. Yields of Dry Matter. Long Rains 1954 *Crop*

Treatment	Yield	Mean yield effects
	tons/acre (*Mean of* 4 *sub plots*)	*tons/acre* (*Mean of* 16)
(1)	2·38	—
N (1 cwt./acre ammonium sulphate)	2·96	not significant
P (1 cwt./acre soda phosphate)	2·67	not significant
C (16 tons/acre cattle manure)	3·92	+1·08
N.P.	3·55	not significant
NC.	3·56	not significant
P.C.	4·05	not significant
N.P.C.	4·34	not significant
K. (1 cwt. muriate of potash)	—	+0·52

Notes—

1. L.S.D. for the cattle manure effect is: 5 per cent=0·58, 1 per cent=0·86; S.E.=±0·25 tons per acre of dry matter.
2. L.S.D. for the potassium effect is: 5 per cent=0·46; S.E.=±0·20 tons per acre of dry matter.

These mean yields of dry matter are rather low because one of the blocks in the experiment did not produce at a very satisfactory level. The cattle manure treatment has resulted in the greatest yield response; cattle manure plus phosphorus together have produced a greater mean yield than either treatment separately. From indications in these results it would seem that a high water-soluble phosphorus fertilizer such as single or double superphosphate might increase the yield more readily than the equivalent soda phosphate application, as the active growing time for the Napier grass is restricted by the length of the rainy season as well as by quantity and distribution. Substantial responses to single and double superphosphate, when applied with nitrogenous fertilizer, have been recorded previously in Napier grass produced on eroded slopes. It is to be noted that the application of 1 cwt. per acre of muriate of potash has significantly increased the dry-matter yield as postulated.

Sub-plot samples of Napier grass from this experiment were submitted to the Spectrographic Department at E.A.A.F.R.O. for analysis of potassium, calcium, magnesium and manganese. Table XVII contains the summarized results: —

TABLE XVII

Plant Nutrient Content of Napier Grass. Yield as lb. per Acre in the Dry Matter. Long Rains 1954 *Crop*

Treatment	Nutrient Element. (Mean Yield of 4 Sub-plots)			
	K	Ca	Mg	Mn
(1)	243·6	7·9	12·4	0·69
N	277·0	7·9	10·9	0·75
P	283·0	6·1	8·4	0·68
C	431·8	8·1	10·2	0·89
NP	383·9	9·5	14·5	0·95
NC	417·3	7·6	11·6	0·91
PC	490·1	9·5	11·9	0·86
NPC	540·1	10·7	15·0	1·03
Mean of – K all treatments	404·6	8·4	11·7	0·88
No K	362·0	8·4	12·0	0·81
Mean increase of uptake	+42·6	0·0	–0·3	+0·07

The treatments which affected the quantity of potassium in the Napier grass were: —

(*a*) *Phosphorus.*—The mean effect of phosphorus on the uptake of potassium was an overall increase of 81.8 lb. per acre. (L.S.D. 5% = 79.6 lb. per acre).

(*b*) *Cattle Manure.*—The mean effect of cattle manure on the uptake of potassium was an overall increase of 173.0 lb. per acre. (L.S.D. 1% = 117.6 lb. per acre).

The increased uptake of potassium on plots which received the potash fertilizer just failed to reach significance at the 5 per cent level. The increased uptake noted is likely to be a real one. There were no significant differences for the calcium, magnesium or manganese data.

The figures follow very closely the dry-matter yields given in Table XVI. The notable exception was the increased uptake of potassium in the presence of the soda phosphate fertilizer. This might conceivably be the indirect effect of the sodium content of this fertilizer and not the phosphorus, i.e. influence of the sodium ion adsorption on to the soil colloid surface.

The figure for the overall mean increase of potassium uptake in the treated sub-plots represents 85 per cent of the added potassium contained in the muriate of potash fertilizer. These potassium figures further emphasize the substantial removal of this nutrient in Napier grass from the production areas. Further experimentation with superphosphate and potash fertilizers is proposed.

Chemical Weed Control in Coffee

Research carried out at this station during the past few years has established two important facts. These are that the control of weed growth in coffee during the rainy seasons and immediately afterwards produces very economic crop yield increases and that repeated mechanical cultivation by disc harrow or plough between the coffee tree rows produces adverse soil tilth conditions. The topsoil becomes fine, dusty, less permeable to the adsorption of rainfall and very inclined to "cap". If not corrected these conditions can have an adverse effect on coffee yields. These two findings are opposed to each other, since frequent mechanical cultivation is the obvious way to control weed growth in coffee. At present the recommended means of controlling weed growth in coffee is either by mechanical cultivation with a specially modified rotary cultivator during and after the rains period, or by hand-slashing the weeds when necessary during the rains followed by a single mechanical cultivation after the rains have ended. Investigations to find a satisfactory chemical weed killer, the use of which would obviate the need for excessive cultivation, the large labour requirements for hand-slashing, and solve the special problem of controlling weed growth through mulches without the destruction of the soil cover, were commenced in 1953.

A full and detailed report has been written and was published in the *Coffee Board of Kenya Monthly Bulletin*, 1954, 19, p. 204, of progress till the end of the long rains 1954. This published report covers the 1953 short rains observation trial, and the results of the 1954 long rains spraying in the formal trial, which has been started. A brief summary of the main points is given here. The chemicals applied in these trials were Pentachlorophenol (P.C.P.) and P.C.P.+2, 4—D mixture. All the chemicals were supplied in an aromatic oil base and both low volume (13¼ gals./acre) and medium volume (38 gals./acre), the latter as a water emulsion, were applied.

From the short rains 1953 observation trial it was found that:—

(1) All the sprays reduced weed growth and the P.C.P.+ 2, 4—D mixture was particularly effective.

(2) This chemical combination was very effective in controlling nut grass (*Cyperus auricomus*).

(3) The control of weed growth through the mulch was very effective and, because of this, an increased effective mulch life was expected.

(4) Low volume applications of these materials are unsatisfactory on account of drift effect.

(5) 2, 4—D effects were noted on young coffee leaf after P.C.P.+2, 4—D applications, particularly where the application was made at a low volume. Subsequent growth put on in the long rains 1954 was not visibly affected.

Samples of coffee were picked and prepared for liquoring by Mr. C. R. Devonshire. He reported the presence of chemical taint (i.e. a "carbolic" flavour and a "bricky" flavour), but the appearance was very irregular and could not be conclusively related to a particular treatment. It was noted, however, that the greatest incidence of chemical taint was recorded for plots with a small weed growth at the time of spraying. Samples of the 1954 crop were picked from these plots and have been submitted again for liquor tests.

Based on these results a full-scale yield trial was put down in mature single-stem coffee prior to the long rains 1954. Rates of application were reduced to 2½ lb. of P.C.P. and 1 lb. acid equivalent 2, 4—D per acre, and the herbicides were applied both singly and combined to help the interpretation of liquor taint results. As a further effort to prevent all drift on to the aerial portion of the trees a medium-volume application rate was adopted and the weedicides were applied with both an open and a protected spray lance. Two spray applications were made over the long rains period, when a total of 24.9 in. of rain was recorded.

The effects of the treatments were assessed by scoring the residual weed growth compared with the uncontrolled weed growth plots. Excellent weed control was obtained by the P.C.P. and P.C.P.+2, 4—D sprays, but spraying 2, 4—D alone had eliminated dicotyledonus weeds but grasses were flourishing. The weeds which were present in the plots in the beginning were onion grass (*Cyperus blysmoides*), nut grass (*Cyperus auricomus*), Devil Thorn (*Oxygonum atriplicifolium*), Mexican marigold (*Tagetes minuta*), MacDonaldii (*Galinsoga parviflora*) and Whispering Willie (*Commelina latifolia*). In the plots sprayed with 2, 4—D alone, the predominant weed growth was altered for mono- and dicotyledons to monocotyledons alone. The most numerous of these were *Dactyloctenium filipes* (annual), *Setaria pallidifusca* (annual) and *Sporobolus filipes* (perennial). The identifications were made by Mr. R. W. Rayner, Plant Pathologist/Physiologist of the Station.

Visual symtoms of the 2, 4—D herbicide were noted after the first spray application on young leaf growth, and on the inside, naturally shaded, leaf growth, so that in August a count was made of the leaf fall from tree pairs in the control and 2, 4—D treated plot. Nine weekly counts were made from August through September and it was found that 13 per cent less leaves fell from the trees in the 2, 4—D-treated plots than in the control, unsprayed, plots. This decrease is statistically significant at the 5 per cent probability level.

The plots were sprayed once only in the short rains 1954, and satisfactory weed control was again noted with the P.C.P. and P.C.P.+2, 4—D herbicides. The trees were carrying no quantity of crop which could be recorded, although sufficient coffee was obtained from the combined pickings to prepare samples for liquoring. No report has been received to date.

The 2, 4—D alone treated plots will be discontinued during 1955 and another type of herbicide will be substituted. Prior to the short rains the plots were mulched in the alternate interrows with Napier grass. There was no weed growth noted in these rows during the short rains, which were very limited. Chemical control of weeds through this mulch will commence with the long rains 1955 spray applications.

Provided that the liquor report concerning chemical tainting in the 1954 samples is entirely favourable the application of P.C.P. or P.C.P.+2, 4—D herbicides in coffee with a protected lance, followed by a normal estate cultivation at the end of the rains, might well be recommended for the control of most weeds. At all times it will be necessary to exercise the greatest possible care to

avoid direct application to the coffee foliage. P.C.P. or P.C.P. + 2, 4 – D herbicide will not eradicate couch grass (*Digitaria scalarum*) unless applied at rates which seriously affect the coffee, although the leafy portions of the grass may be wholly or partly killed.

Miscellaneous Investigations

Mineral Nutrition of Coffee

Informtion on the mineral nutrition of coffee growing under natural condition of soil and climate is of fundamental importance, and the opportunity of obtaining this type of data has been taken whenever possible. It would be a valuable asset if the answers to such questions as; what are the normal trends of mineral nutrition in coffee as reflected by leaf analysis values in relation to climatic changes of season? and the degree of cropping? and what are the effects of applied field treatments such as manures, irrigation and mulches? were known.

It has not been possible to undertake full and exhaustive studies along these lines and the scant information in this section has been obtained where and when the time and opportunity has presented itself.

Cattle Manure

Attention was invited to some striking growth differences of mature single- and multi-stem coffee (mixed) growing in the Lower Kiambu area during the long rains 1954, where a small area adjacent to some dairy buildings had received the dairy sweepings since December, 1952. In May, 1954, the difference in growth between this area and the coffee surrounding it in the same field was very marked. General comparative observation showed that growth on the coffee in this area amounted to three pairs of leaves, with a fourth pair emerging, whereas the surrounding untreated coffee had only produced two pairs of leaves, with or without one unopened pair. The young growth of the untreated coffee was distorted and the leaves were crimped and crinkled as in the condition termed "hot and cold" effect. The coffee generally was carrying a good potential crop. It was estimated that the dairy sweepings had amounted to a total dressing greater than 50 tons per acre and probably greater than 100 tons per acre. Three sets of leaf samples, first pair of fully open leaves on the secondaries of mature single-stem trees, were taken from the normally treated coffee area and three from the area which had received the dairy sweepings. The analyses for potassium, calcium, magnesium and manganese were made by the Spectrographic Department of E.A.A.F.R.O.

Table XVIII

Coffee Leaf Analyses. (*Per cent Dry Matter*)

(*Mean and Range of Samples*)

Treatment	N	P	K	Ca	Mg	Mn. (ppm)
No C.M. ..	3·29 ± ·03	0·521 ± ·017	3·91 ± ·33	0·178 ± ·041	0·287 ± ·026	65·4 ± 13
C.M. ..	3·59 ± ·81	0·503 ± ·034	4·33 ± ·13	0·217 ± ·033	0·309 ± ·014	139·6 ± 11

Note.—C.M. denotes dairy sweepings.

The coffee which received the dairy sweepings made more growth and absorbed greater amounts of plant nutrients, but there were no large differences in leaf mineral contents expressed as percentage of dry matter, except for manganese content which had been increased by the dairy sweepings. Apart from

the manganese added in the sweepings, biological reduction of unavailable manganic oxides in the soil may have influenced the amount of this chemical in the leaves. The application of the sweepings, equivalent to an application of farmyard manure or *boma* manure far in excess of that which would be feasible or economic on a field scale, certainly made larger quantities of nutrients available and increased growth, but the better growth does not seem to be related to any of the nutrients shown in the table, with the possible exception of manganese.

MAGNESIUM

It is a common thing to observe a type of chlorosis on the older pairs of coffee leaves following rapid vegetative growth. These leaves seem to be shed prematurely, and it was postulated that the forced withdrawal of some nutrient, or nutrients, in short supply during the growth period might be the cause. A description of the development and pattern of the leaf chlorosis in the early stages would be in substantial agreement with a shortage of available magnesium. Distortion of young leaf growth is also to be observed at this time and might be attributed to a shortage of available magnesium and/or calcium.

It was decided to examine the effect of an application of a magnesium salt in terms of the percentage content of certain minerals in the leaf. Magnesium sulphate (commercial Epsom-salt) was applied at the rate of 40 lb. per acre to five pairs of mature multi-stem trees in May, 1954. Five untreated pairs of trees were retained as controls. The salt was scattered in a circular band around the tree at a distance of 2–3 ft. from the trunk and was raked into the topsoil. Leaf samples were collected three months later, the first pair of fully open leaves behind the spear, on the primaries, was sampled. Unfortunately, only one set of samples was collected. These were analysed by the Spectrographic Department of E.A.A.F.R.O. The results are given in Table XIX:—

TABLE XIX

Magnesium Experiment. Coffee Leaf Analysis

(*Per cent Dry Matter*)

Treatment and sample Number		K	Ca	Mg	Mn (ppm. D.M.)
Mg.	1.	2·74	0·702	0·317	179
	3.	2·51	0·717	0·381	184
	5.	2·68	0·457	0·338	155
	7.	2·54	0·657	0·340	134
	9.	2·41	0·614	0·240	68
Mean		2·58	0·630	0·323	144
(1)	2.	2·63	0·605	0·419	192
	4.	2·77	0·518	0·325	166
	6.	2·60	0·471	0·339	135
	8.	2·71	0·495	0·254	76
	10.	2·38	0·392	0·274	70
Mean		2·62	0·496	0·322	128

NOTE.—The mean difference for Ca just fails to reach the 5 per cent level of significance.

The ten pairs of trees were sited on the side of a small ridge of coffee, and run downhill from tree pair No. 1 to tree pair No. 10. The slope is approximately 5 per cent, and some topsoil movement has taken place in the past. The nutrient content of the leaves shows a marked decrease from tree pair No. 1 to tree pair No. 10, i.e. as you proceed down slope, with the notable exception of the calcium values of tree pairs which were dressed with magnesium. The addition of magnesium seems to have resulted in increased calcium uptake. For the sake of completeness cherry weights were recorded for each tree pair during the 1954 picking season, but there was no great difference between the mean treatment values. Leaf sample variation was large despite the care taken at the time of sampling. These treatments will be repeated in 1955 with, if possible, more frequent leaf sampling.

Green Vein Chlorosis

It is frequently observed on mature coffee in the field that all or part of the young leaf growth has developed a yellowing or chlorosis. The symptoms, termed by us "green vein chlorosis", are in the early stages paleness of the interveinal leaf areas. With increasing severity, these areas become progressively paler in colour and eventually yellow. In the final stages complete absence of chlorophyl occurs but the leaf veins remain a healthy green colour and stand out more clearly as the symptom develops. In very extreme cases, the finer parts of the vein network become bleached in a manner similar to the interveinal leaf areas. The symptoms described occur most frequently on young leafage produced at a time of rapid growth. Under natural climatic conditions the greatest incidence has been observed on young suckers following rapid growth during the long rains period, and on leaves of mature coffee trees which carry little or no crop and which has produced rapid and luxurious leafage. Later in the year, August–September, mature leaves exhibiting symptoms of green vein chlorosis often occur behind the youngest pair of fully open green leaves whilst older pairs of leaves are green and apparently healthy.

During 1953 and 1954 diagnostic leaf injection with certain suspected micro-nutrient elements was carried out and it was found that iron as ferrous sulphate was the only nutrient tested which gave any response at all. In 1954 full recovery of natural green leaf colour was observed in response to iron injections, and it was concluded that the symptoms arose from a lack of available iron for adequate leaf metabolism. The symptoms of green vein chlorosis have been observed to occur during periods of rapid vegetative growth. A full technical report on this subject has been published in the *East African Agricultural Journal*, 1955.

A Rapid Method for Determining the Effective Depth of Coffee Soils

During 1954 an occasion arose when it became desirable to make a survey of the effective soil depth on some areas of the Rukera Demonstration Farm. Digging soil pits, or augering by hand were methods which because of the time factor would not serve the required purpose, and it was necessary to develop a new and rapid method. With Mr. E. Cottington, Senior Assistant Agricultural Officer (Coffee), a rapid method was devised and used successfully. Eventually the whole coffee area on the Rukera Demonstration Farm was examined by the method and the recorded soil depths mapped.

With this method, termed the soil probe method, it is possible to detect within the Kikuyu red loam coffee soil profile the presence and thickness of loose pisolitic murram layers, the presence of murramy topsoil and subsoil, i.e. soil containing occasional pisolitic murram particles and, finally, the soil depth

to parent rock or hard sheet murram, as the case may be. The method is both simple and rapid and yields information of the soil depth which is essential for assigning, where necessary, mulch and irrigation priorities and for examining the soil depth of marginal coffee-producing areas as well as for the sites of proposed new coffee plantings. A full and detailed account of the method has been published in the *Bulletin of the Coffee Board of Kenya*, 1955, 20, 14.

The Determination of Moisture in Parchment and Clean Green Coffee Samples

This work was concerned with defining a suitable basic laboratory technique for the accurate determination of free water in both parchment and clean green coffee samples.

Preliminary data showed that if drying to a constant weight is carried out in an air oven at 100° C. the parchment and the beans take on a part-roasted appearance and it was apparent that considerable thermal decomposition occured. The air oven method at a temperature of 100° C. would not, therefore, be a satisfactory one for calibration purposes. It was subsequently shown that the maximum temperature for drying at which no apparent part-roasting occurred was 62° C., but whole bean samples of clean green coffee dried at this temperature in an air oven for approximately 12 days had not attained a constant weight at the end of this period. The same clean green coffee samples were also examined with an electrical (Marconi) moisture meter. A manufacturer's calibration chart was available for coffee, but the calibration drying had been carried out in an air oven at a temperature of 105° C. and the results obtained would be greater than the true moisture values. The comparison between results obtained by drying at 62° C. for 12 days and by the Marconi Moisture Meter were highly and significantly correlated, though the Marconi Moisture Meter results were considerably greater. One of the disadvantages of using the small standard size grain cell which had only a very small volume was that the samples had to be ground up to provide reproducible readings. In this instance an electrically operated micro Wiley mill was used for the purpose very successfully. The results showed that this electrical instrument could provide satisfactory results over the lower moisture ranges (5–20 per cent) if a new calibration were made using an acceptable basic technique. A further improvement would be the use of an electrical cell of larger volume.

A comparison was carried out between clean green coffee samples dried at 100° C. and 62° C. in an air oven, to constant weight. After 13 days' drying the values found at 62° C. did not nearly approach those obtained at 100° C. after only 24 hours. At this stage it was apparent that air-oven drying was not a satisfactory technique for the determination of true moisture content, but it was appreciated that the results obtained by using a carefully standardized procedure could be related to the true moisture content value of the sample through some other basic technique.

With the decision by the Coffee Board to finance research into artificial coffee drying it was more than ever necessary to find a method of determining the true moisture content of laboratory samples over a wide range of moisture. Such a method would provide the necessary reference data which would relate values obtained by a selected rapid field method to the true moisture values of samples taken during drying tests, etc.

Information and suggestions concerning the problem were forthcoming from Dr. Barnell and Mr. E. G. B. Gooding of the Ministry of Food Research Establishment in Aberdeen, and from Mr. P. de Lange, Director of the Central Nutrition Research Institute, Utrecht, who discussed the subject with Mr. F. C.

Coolhaas, Director of the Tropical Agricultural Laboratory at Wageningen, and Dr. J. J. I. Spenger of the Central Institute of Agricultural Research, Holland. Published Amercian research on this subject at the time, by direct chemical determination of the water (Karl Fischer Reagent), had shown that practical difficulties could be expected with the extraction stage and this method was not therefore examined.

Acting on the information received from the above sources comparisons of several methods and techniques were made over a wide moisture content range with parchment coffees. Finally, a vacuum-oven technique was found which gives highly reproducible results and moisture figures which are as close as possible to the true values. The technique has been in use for the routine determination of moisture in both parchment and clean green coffees during the past season's coffee-drying investigations as a reference method. A description of the technique as finalized is given here in some detail:—

> "In order to reduce the possibility of moisture loss during grinding whole-bean samples of parchment coffee with moisture contents greater than 18–20 per cent are pre-dried in an ordinary air oven at 95–100° C. for one hour. 10 gm.–15 gm. sample weights are taken and the drying is carried out in circular aluminium containers fitted with a tight lid. (The dimensions are height 4.5 cm., diameter 6.5 cm.) After cooling in a dessicator and weighing these samples are ground as described hereafter, and sub-sampled for the final drying operation.
>
> Samples of parchment or clean coffee beans are ground in an electrically operated micro-Wiley mill, to pass a 20-mesh (U.S.A. standard size) sieve, the ground material being collected in covered glass jars. Samples of 5 gm. in weight are taken and dried in a vacuum oven at 70° C. and 54 cm. Hg. for eight hours. The samples are dried in circular aluminium containers as described above and are weighed finally after cooling in a dessicator. All weighings are carried out to the fifth (estimated) decimal place, and the final moisture content is corrected to the second or first decimal place depending on the degree of accuracy required. Percentage moisture values are expressed on the basis of the original wet weight of the sample. All weighings and manipulations (except the actual drying) are performed with the lids of the circular containers fitted tightly to prevent moisture loss or uptake from the external atmosphere."

As an example of the accuracy that may be expected the standard deviation of a set routine of determinations for parchment coffees (expressed at per cent original wet weight) over the range of 12–14 per cent was: $\sigma = 0.12$ per cent; S.E. mean of three replicate determinations $= \pm 0.09$ per cent; average difference to be expected between duplicates $= 0.14$ per cent.

Laboratory Characteristics of Coffee Liquors

This study was initiated with the long-term objective of investigating possible relationships between chemical characteristics of coffee liquors and the occurrence of taints. Undesirable taints, as, for example, severe "onion" flavour, occur from time to time in a coffee for no readily accountable reason, and may severely reduce the market value of that particular consignment, whilst also reducing the revenue of the estate concerned.

With the ready co-operation and assistance of Mr. C. R. Devonshire, Liquorer to the Coffee Board of Kenya, samples of coffee liquors were prepared by him in the normal routine manner in the liquoring department. The preliminary study reported here was confined to normal, i.e. untainted, coffee liquors to ascertain whether certain simple analytical procedures would differentiate coffees of

variable quality and roast on a rather broad basis. Accordingly, the liquors were related to three general quality classes and three degrees of roasting. The quality of the selected coffee samples, which had been previously classified, was: (1) medium–good; (2) F.A.Q.; and (3) poor, and the samples were roasted to three different levels which were (1) light, liquoring roast, (2) medium-light, domestic roast, and (3) full, continental roast. It was planned to include three individual samples of each quality, but at the time of preparing the liquors only one medium-good quality coffee was available. In the following results therefore the statistical comparisons have been confined to data for the F.A.Q. and poor-quality samples, though the single-sample analysis of the medium-good quality coffee is included for comparison purposes. The means results of the laboratory tests are given in Table XX:—

TABLE XX

Coffee Liquor Analyses

Roasts (Means of 6)

Factor	Liquoring Roast	Domestic Roast	Continental Roast	L.S.D.'s
pH value	4·99	5·06	5·38	5%=0·15% 1%=0·32%
(Specific Acidity) ..	(102)	(87)	(42)	—
Colour	28·0	34·4	51·9	5%=4·8 1%=10·0
Total Soluble Extractives	0·9908	1·0650	1·2297	5%=0·0877 1%=0·1807

Coffee Qualities. (Means of 9)

Factor	F.A.Q.	Poor	L.S.D.s
pH value	5·13	5·16	not significant
Colour	35·9	40·3	1%=4·0
Total Soluble Extractives ..	1·0807	1·1096	not significant

Values for a Single Sample of Medium—Good Quality Coffee Liquor

Factor	Liquoring Roast	Domestic Roast	Continental Roast
pH	4·77	4·88	5·28
Colour	29·8	38·5	58·2
Total Soluble Extractives ..	1·1044	1·2022	1·3694

NOTES.—(1) Total soluble extractives are expressed as grms./100 ml. liquor.

(2) Colour was measured in terms of optical density using a green filter against a water setting equal to 100 per cent transmission.

Summarizing, it is evident that the degree of roast has had a far greater influence on the liquors than the inherent overall quality of the coffees. As the strength of the roast increased acidity decreased, the liquor colour became darker and the total soluble extractives increased per unit volume of liquor. It is interesting to note that the single values for the medium-good quality coffee liquor show, when compared with the F.A.Q. and poor-quality coffee means for the same degree of roast greater acidity, greater colour and more total soluble extractive per unit volume, or greater acidity with more body to the liquor.

The body of a coffee liquor increases with the fullness of roast. In these samples this is reflected by the total soluble extractives which also increase with fuller roasting. A very strong positive correlation was found between colour and total soluble extractives (+0.91, sig. at 0.1 per cent level). The regression equation for colour on total soluble extractives was $x = 80.4317, -49.9888\ y$, and the regression coefficient, $bxy = 80.4317$, was significant at the 0.1 per cent level. The colour of the liquors was very closely related to the total soluble extractives and hence to the "body" of the liquors.

A single liquor sample of a coffee classed as "very common" was examined in the manner reported above. It had been roasted lightly (liquoring roast) and the results were pH = 5.29, colour = 35; total soluble extractives = 1.0368 grms./100 ml. These values were much nearer to the mean values for the domestic and continental type (full) roasts (Table XX), and the liquor lacked acidity.

This work is being continued.

The Cultivation and Cropping of Vlei Soils

In many coffee areas, and on many coffee estates, one of the most serious drawbacks to the adequate production of suitable quantities of Napier grass for mulching the coffee is a shortage of available land. This statement refers to red soils, i.e. Kikuyu red loam soil series, but does not include the considerable acreages of vlei or "bottom" land situated between the ridges of red coffee soil.

The vlei areas would become an extremely valuable asset to the coffee planter if they could be brought into Napier grass production. The problem is primarily a physical one, and practically they are described as being either too wet or too dry under natural conditions to support more than a sparse grass or grass-cum-scrub vegetation. Genetically they are very heterogenous, vary greatly in their mechanical composition and exhibit strong "gley"-type features in the profile. Some occur with loose pisolitic murram and hard murram within 6–9 in. of the soil surface, but this seems in the writer's experience to be the exception and not the rule. Mostly they consist of a lighter, often murramy, topsoil overlying some 2–3 ft. or more of heavy expanding lattice-type clay subsoil. Perched water tables within the profile are a frequent phenomenon during the rainy season, the soil above the impervious layer becoming super-saturated with water.

Flat ploughing and cultivation during the dry months is of little value for stimulating economic crop production because of the severe waterlogging which occurs after the first rain has fallen. A system of ridge cultivation was an obvious choice for trial, and it was decided to examine the "camber bed" system of cultivation, which is successfully used on poorly drained clay soils in the British West Indies to increase sugar production. This trial was commenced in February, 1954, with the co-operation of Mr. T. R. Brook, Officer-in-Charge Soil Conservation Service, Ruiru, and Mr. H. H. J. de Vink, A.A.O. (Experiments), Coffee Research Station.

It is not proposed to describe the cultivation system in detail here but a full description for publication is being prepared at present. Suffice it to say that after deciding on the desired width of bed, and having completed a survey to define the correct main drainage layout for the area, a sequence of cultural operations is carried out to produce a raised bed with a convex surface. The sequence of cultivation operations is such that the bed is raised above the semi-pervious clay subsoil, the uncultivated surface of which has a reflected, slightly convex surface. This ensures good lateral drainage of excess water which percolates down through the cultivated soil layer, and prevents the formation of a perched water table. All cultivation operations must follow the desired direction of fall in the drainage system to ensure the most rapid removal of excess moisture. The finished camber bed sheds excessive water from its cambered surface and water drains from the reflected camber of the uncultivated subsoils into the bed drains and ultimately into the main drains.

Such a sequence of operations was carried out in the construction of 24 ft.-wide cambered beds for the experiment by Mr. T. R. Brook and Mr. A. Mundy (Farm Manager, C.R.S.). Because there had apparently been little or no previous success with cropping these areas in the past, yellow maize was planted for the long rains 1954 season to determine whether there might be either some gross nutrient deficiency or a toxic chemical factor, or factors, which would prevent reasonable crop growth. The fertilizer and manurial treatments examined were nitrogen as ammonium sulphate (2 cwt. per acre), phosphorus as double superphosphate (1 cwt. per acre) and cattle manure at the rate of 20 tons per acre. A liming treatment was not included because the results of pH tests did not show the presence of unduly acid soil conditions. The experimental design adopted was a 2^3 factorial layout with three replications. In the short rains 1954 field beans were grown to supply more yield data for this type of land. The N and P fertilizer dressings were repeated, but not the cattle manure application. The yield data are presented in Tables XXI, XXII and XXIII:—

TABLE XXI

Cob (Maize) Long Rains, 1954

Treatment	Yield	Yield effect
	Cwt./acre (Means of 3 replicates)	*cwt./acre (Means of 12)*
(1)	7·03 (3·2)	—
N	15·31 (6·9)	+4·27 (1·9)
P	17·65 (7·9)	+6·89 (3·1)
C	34·75 (15·6)	+22·73 (10·2)
NP	20·71 (9·3)	not significant
NC	35·29 (15·8)	not significant
PC	38·18 (17·1)	not significant
NPC	43·39 (19·4)	not significant

NOTES—

N=Sulphate of Ammonia, 2 cwt./acre.
P=Double Superphosphate 1 cwt./acre.
C=Cattle Manure straight from the Cattle pens at 20 tons/acre/annum.
SE for yield effects=±1·82 cwt./acre.
LSD for yield effects=5 per cent=3·89 cwt./acre.
1 per cent=5·44 cwt./acre.
·1 per cent=7·51 cwt./acre.

Figures in brackets are yields of 200 lb. bags of maize per acre.

TABLE XXII

Stover. (Maize—Sun Dried)
Long Rains, 1954

Treatment	Yield	Yield effects
	tons/acre (Means of 3 replicates)	*tons/acre (Means of 12)*
(1)	0·93	—
N	2·24	0·89
P	1·28	0·74
C	4·12	2·95
NP	3·18	not significant
NC	4·72	not significant
PC	4·87	not significant
NPC	5·69	not significant

NOTES—

N, P and C denote fertilizer and manurial dressings as in Table XXI.
SE for yield effects = ±0·23 tons/acre.
LSD for yield effects = 5 per cent = 0·50 tons/acre.
1 per cent = 0·70 tons/acre.
·1 per cent = 0·97 tons/acre.

TABLE XXIII

Field Beans (Haricot). Short Rains, 1954

Treatment	Yield	Yield effects
	bags/acre (threshed beans) (Means of 3 replicates)	*bags/acre (Means of 12)*
(1)	0·36	—
N	0·39	not significant
P	1·90	+1·07
C	1·28	+0·50
NP	1·62	not significant
NC	1·10	not significant
PC	1·83	—0·32
NPC	2·05	not significant

NOTES—

N = Sulphate of Ammonia 2 cwt./acre.
P = Double superphosphate 1 cwt./acre.
C = Residual effects of long rain application.
SE for yield effects = ±0·09 bags/acre.
LSD for yield effects 5 per cent = 0·20 bags/acre.
1 per cent = 0·28 bags/acre.
·1 per cent = 0·39 bags·acre.
A bag = 200 lb.

The results in these tables were recorded and prepared by Mr. H. H. J. de Vink, A.A.O. (Expts.)

The yields of maize recorded in the long rains 1954 (approximately 25 in. of rainfall) were average on the C, NC, PC and NPC treated plots. Substantial yield responses of both corn on the cob and stover were obtained for the NP and C treatments, but the first and second order interaction effects did not reach the level of significance.

Yields of field beans (haricot) recorded in the short rains 1954 (approximately 5½ in. of rainfall, of which the first one to two inches were recorded as light showers and were not very effective) showed significant responses to the P and residual C treatments, but the combination of P+C did not raise the yield to the expected level (significant negative interaction). The visual effect of the P treatment in the early stages of growth was very striking. The crop on all plots which had received P was much more forward in growth and this enabled it to use the sparse rainfall to produce a greater yield. The value of P fertilizer supplied to a legume crop grown on this soil is well demonstrated, particularly under drought conditions.

During the long rains 1954 soil samples were taken by auger at quite arbitrarily selected vertical intervals on the camber beds and on the adjacent uncultivated vlei area, and the moisture content determined. In each case three separate augerings were bulked for the soil moisture determinations. The soil moisture values of successive depth intervals were considered to be a reliable and practical method of comparing the physical effect of the cultivation on the internal drainage of the cambered bed in comparison with the uncultivated vlei soil.

The results of the first sampling, which was carried out after 3 in. of rain had fallen, demonstrate that whilst on the camber beds the soil moisture content decreased with depth, on the uncultivated vlei the moisture content had increased to the supersaturated 12–18 in. layer, and then dropped markedly in the 18–24 in. layer. This was caused by the formation of a perched water table over the 18–24 in. layer and reflected the inadequate drainage in the profile at this point. The differences in actual soil moisture values between the two areas is a reflection of the different physical condition of the soil, that of the camber bed being more open as a result of the cultivation. This contrast is more pronounced between the upper pair of histograms.

The perched water table effect still persisted at the time when the second sets of samples were taken one month later. A total of 9.0 in. of rainfall had been recorded in the interval. The camber bed samples now show a general increase in soil moisture content with depth, more typical of a naturally free draining profile. In the uncultivated vlei the vertical distribution pattern is similar to that of the first set of samples taken. This determination of vertical moisture distribution can be used on the camber bed cultivation system to determine the loss of soil tilth which will inevitably take place with time from the bottom upwards, and serves to emphasize the time when recultivation of the beds is necessary if crop yields are to be maintained.

Fermentation Studies with Cattle Manures

An investigation was undertaken, in collaboration with Mr. B. Butters, Agricultural Chemist at the Scott Laboratories, to study the effects of composting together cattle manure and Uganda rock phosphate, on the available phosphorus and nitrogen in the final material. Uganda rock phosphate is a cheap form of phosphate fertilizer readily available locally. Since phosphorus is a plant nutrient to which a wide range of crops on a variety of Kenya soil types respond economically, raising the available phosphorus in cattle manure by this method would be of practical value. In practice the addition could be made by dressing the bedding in the cattle pens. Uganda rock phosphate is a material which is available for agricultural use, but which has only a small content of readily soluble phosphorus. The immediate crop response to Uganda rock phosphate dressings is normally less than that to either soda phosphate or superphosphate at equivalent rates of phosphorus

application. In this instance random samples from the four bags of Uganda rock phosphate set aside for the experiment gave the following analyses; and it will be noted that the citric soluble P_2O_5 is only a small proportion of the total P_2O_5 content.

TABLE XXIV

Total and Citric Soluble Phosphorus Content of Uganda Rock Phosphate Samples

Sample	Total P_2O_5	Citric Soluble P_2O_5
	per cent	*per cent*
1	26·6	3·66
2	28·7	3·94
3	24·4	3·09
4	21·4	3·91

NOTE.—Analyses were carried out by Mr. B. Butters using method of Pons et al. (J. A.O.A.C 1953. 36. 492).

The cattle manure (long, one month in night *boma*) was composted in weighed heaps with an overall dimension of approximately 5 ft. by 5 ft. square on concrete aprons. Each apron was sloped to the centre and forward to provide for adequate effluent drainage which could be collected for analysis. Fermentation temperatures were recorded daily at 9 a.m. with a thermometer suspended inside a half-inch diameter glass rod inserted into the middle of the heap.

The experimental layout consisted of two replications of cattle manure alone and cattle manure with rock phosphate. On the advice of Mr. P. Robinson, Statistician at E.A.A.F.R.O., samples for laboratory analysis were taken from four quarters of a heap (divided up by eye), three samples from each quarter giving a total of 12 samples from each heap. One of each of the two replicates was thatched to shed possible rainfall and one was left uncovered. In fact, as so very little rain fell during the time of the experiment, small volumes of water had to be added to the heaps on two occasions. Cattle manure samples, which were taken before and after fermentation, were analysed for moisture content and total nitrogen in this laboratory. Sub-samples were submitted at the same time to Mr. B. Butters for phosphorus fractionation analysis. The latter results are not completely available at the time of writing.

The first differences to be noted between the treatments were those of fermentation temperature. Differences between replicates of the same treatments were small or non-existent compared with differences between the treatments. A comparison of the mean temperature curves shows (1) an initial temperature rise over the first two days, (2) a steady temperature decrease for approximately three weeks, i.e. C.M. 35–40° C. → 30–35° C., C.M. + U.R.P. 55–60° C. → 40–45° C., (3) a period of steady temperature levels for a further three weeks, (4) a final decrease to the level at which the heaps were opened up, weighed and sampled. Whilst the shape of the curves were similar, temperatures were very much greater for the C.M.+U.R.P. treatments. The moisture content, total dry matter in the heaps by calculation, and nitrogen per cent dry matter are given in Table XXV:—

TABLE XXV

C.M.±U.R.P. Experiment Data

C.M. Treatment Heaps	Moisture Content of C.M. (Means of 12)		Weight of Dry Matter in Heap (lb.)		N (% DM.) (Means of 12)		Total lb. N in Heaps	
	1	2	1	2	1	2	1	2
A. C.M.	29·7	70·2	1479·8	272·3	1·586	1·420*	9·33	1·92
B. C.M. (Covered)	30·5	73·3	1599·2	246·3	1·571	1·335*	10·18	1·84
C. C.M.+U.R.P.	35·4	68·6	1256·5	251·5	1·260	1·257	9·97	2·00
D. C.M.+U.R.P. (Covered)	31·0	69·0	1498·0	322·8	1·269	1·431 †	11·8	2·26

NOTES—

1. Subsection 1 under each heading denotes data determined prior to fermentation, and subsection 2, data determined after the fermentation period.
2. *=significant decrease in nitrogen per cent dry matter after fermentation.
3. †=Significant increase in nitrogen per cent dry matter after fermentation.
4. L.S.D. 5 per cent=0·161 per cent; SE=±0·076 per cent nitrogen in dry matter.
5. The percentage by weight, of added U.R.P. in heaps C and D was 2·9 per cent and 2·4 per cent respectively.

During a period of two and a half months' fermentation about 81 per cent of the dry matter and 74 per cent of the nitrogen by weight remains unaccounted for. Despite the higher fermentation temperature for most of the period, greater losses of dry matter and nitrogen were not recorded for the C.M.+U.R.P. treatment, and in fact less dry matter was unaccounted for in this treatment than in the untreated C.M. heaps. The data emphasise the problem of bulk loss of dry matter when cattle manure is allowed to remain standing in heaps for a long period of time.

The cattle manure from the four heaps after fermentation was completed was tested with a maize crop grown in pots. A Kikuyu red loam soil was used in the test as corn is known to respond to added phosphate, particularly in the presence of nitrogen on this soil. Two replications of a 4 × 3 × 2 layout were set up. Unfortunately no potting shed was available to house the pots, which were made of compressed cellulose fibre treated with bituminous paint, and treatments had to be harvested prematurely because of damage caused by rain and dogs. The improvised outdoor shelter was inadequate. The yield results of green matter and dry matter when examined statistically, showed significant responses to added nitrogen, equal to 2 cwt. per acre and ammonium sulphate, and to different rates of cattle manure, equal to 10 and 20 tons per acre, but there was no response to phosphated as against non-phosphated cattle manure. This might have been the result of premature harvesting. Further work will be carried out, but the fermentation time will be reduced to decrease losses of dry matter and nitrogen.

Acknowledgments

I wish to acknowledge the assistance of Mr. G. T. Chamberlain, Spectroscopist at E.A.A.F.R.O., for analysing submitted plant material; of Mr. C. R. Devonshire, Liquorer, Coffee Board of Kenya, for his very willing co-operation in experimental work requiring the assessment of coffee liquors; and particularly of Mr. H. H. J. de Vink, Assistant Agricultural Officer (Experiments), Coffee Research Station, for every possible help in the field work involved with some of the experiments. Finally, I wish to acknowledge the excellent standard of laboratory work carried out by Mr. D. Mwae.

Publications

(1) "A Note on Sulphate of Ammonia Application to Coffee", *Bull. Coff. Bd. Kenya,* 1954, 19, 58.

(2) "Report on the Progress Made with Chemical Control of Weeds in Coffee", *Bull. Coff. Bd. Kenya,* 1954, 19, 204.

(3) "A Note on Green Vein Chlorosis of Coffee", *E.A. agric. J.,* 1955, 20, 195.

(4) "A Simple Method of Determining Soil Depth in Coffee Soils", *Bull. Coff. Bd. Kenya,* 1955, 20, 14 (with E. Cottington, Esq.).

J. B. D. ROBINSON,
Agricultural Chemist (Coffee Services).

Note.—Prepared graphs which would have made the above article clearer have unavoidably been omitted.

GRASSLAND RESEARCH—ANNUAL REPORT FOR 1954

Introduction

Substantial progress has been made during the year in spite of shortage of staff due to call-up for the Emergency, and also to various officers being on long leave for parts of the year. The call-up has claimed five officers, namely four field staff and one laboratory assistant, all for about a year now, with the prospect of a total of two years in the forces for each of them.

No funds for development and non-recurrent expenditure were available during the year, with the result that development work was restricted and no new equipment could be purchased. The lack of adequate storage for seeds, fertilizers, implements and equipment frequently caused problems.

Nevertheless, a large programme of work has been carried out during the year, and notable progress has been made in the following lines of work: ley species for a range of altitudes, seed production of a promising indigenous clover for pasture legume purposes, improved seed production of Rhodes grass, green fodder grass for dry season keep, and preliminary work on the problem of nitrogen fixation in legumes. It is considered that the main search for ley species for the high rainfall mixed farming areas is largely over, and the next phase is that of selecting improved varieties, particularly in regard to seeding qualities. While this is going on, work needs to be done on the establishment of grass-clover mixtures, and their management, as we now seem to have a clover available for use in extended trials, and also an adequate supply of seed for this purpose at present. Establishment and management problems of a grass-legume mixture will certainly differ from those of a pure grass ley and the matter now needs to be dealt with. In general the preliminary and exploratory stage seems to have passed in our work at Kitale and Molo, and the lines of approach for the future are becoming apparent.

The programme of investigations is a large one, and comprises numerous experiments at Kitale, Molo and on various farms elsewhere. In this report, only those are mentioned which have produced useful and fairly definite results up to date. The remainder are dealt with very briefly in a supplementary progress report which will not be published.

Rainfall

The following table shows the monthly rainfall and the number of rainy days during the year, and the figures for 1952 and 1953 are also given for purposes of comparison:—

TABLE I

Month	1952		1953		1954	
	Rainfall	No. of rainy days	Rainfall	No. of rainy days	Rainfall	No. of rainy days
January ..	Nil	—	0·14	1	0·24	2
February ..	0·20	4	0·16	1	1·17	3
March ..	4·69	10	0·50	4	3·26	7
April ..	7·53	22	5·84	18	4·80	15
May ..	7·25	22	7·23	12	5·52	22
June ..	2·85	12	6·86	21	4·59	16
July ..	2·92	18	3·26	16	5·31	18
August ..	6·91	21	5·89	15	5·71	25
September ..	2·45	13	1·20	7	5·28	14
October ..	4·52	16	3·32	16	1·69	12
November ..	1·33	12	1·85	14	1·45	5
December ..	0·05	2	1·02	8	2·32	6
TOTAL ..	40·70	152	37·27	133	41·31	145

The mean for Kitale is 46 inches.

The season has not been unsatisfactory on the whole. The rains were rather patchy and erratic in April and May for planting purposes, but the hot, dry spells in between were not too prolonged to cause trouble. In much of the Colony, the rainfall was above average, but at Kitale on the Grassland Station it was nearly 6 in. below the mean.

Work at Kitale

(1) Plant Introduction and Nursery Work

Over 300 new introductions were made during the year (1954), and of these some were collected locally in Kenya, but most of them came chiefly from the U.S.A., Nigeria, Australia, Southern Rhodesia and Venezuela. The total number of different plots in the nursery was 1,400. Numerous varieties of each of the main grasses were grown in the nursery and their characteristics were studied from the agronomic point of view. These were Rhodes grass (*Chloris gayana*), Molasses grass (*Melinis minutiflora*), Guinea grass (*Panicum maximum*), Star grass (*Cynodon* spp.), *Setaria sphacelata*, *Setaria splendida*, Signal grass (*Brachiaria brizantha*), *Cenchrus ciliaris*, and Elephant grass (*Pennisetum purpureum*).

Among the more vigorous types of Guinea grass, which are specially suitable for cutting purposes, though also for grazing, the following were the outstanding ones: K.51285 from Wei Wei River, Kenya, which gave 13 cuts at the grazing stage, K.52530 and K.52531, both from Sigor, Kenya, and K.52125, from Lilongwe, Nyasaland, which was particularly leafy. The seeding qualities of these strains are less satisfactory, and their establishment from seed is often erratic, and the problem is being investigated. A thin-stemmed variety of Guinea grass, var. *trichoglume*, which is a smaller and finer type in general use in Australia, also gave satisfactory results. Both strains of this were obtained from that continent.

Of the Rhodes grass varieties, K.51246, from Chepararia, Kenya, and K.53166, from Mbarara, Uganda, showed up particularly well both in the nursery plots and in grazing plots. In the latter, 23 different strains of Rhodes grass are being compared under grazing, with a view to selecting those most resistant to grazing. Vigorous grazing management will eliminate those strains which are least satisfactory in this respect, and, later on, the remaining ones can be compared more critically. K.52364, from Kabarnet, Kenya, comes from a dry area and belongs to the same type as Rongai Rhodes grass, which is in commercial use, but the Kabarnet variety certainly seems to be superior. The well-known Nzoia strain of Rhodes grass was slightly disappointing, not being very stoloniferous, and it produced patchy growth easily invaded by weeds.

Among the varieties of Molasses grass in the nursery, K.53608, from Nigeria, was the best, producing vigorous and leafy herbage and also recovering rapidly after clipping at the grazing stage. Good results were also obtained from the Kitale commercial type and the variety from Endebess, Kenya.

Setaria splendida is a grass of high quality, suitable for grazing but specially for cutting, which remains green and quite succulent well into the dry season. A few clones which have been selected and examined critically, seem most promising, except for their seeding qualities.

Nandi *Setaria*, the most promising of our new pasture grasses and now in an advanced stage of multiplication prior to use on a wider scale, has been the subject

of selection work, and improved leafy types which recover quickly after defoliation have been obtained. A considerable amount of breeding work may, however, be necessary to get the type fixed.

Among new species under preliminary trial, *Paspalum malacophyllum* produced abundant foliage and flowered well, but its seeding qualities were disappointing. *Paspalum regnelii*, a little less productive than the previous species, produced plenty of good quality seed. *Pennisetum dowsonii*, a grass of potential value for waterlogged soils, gave good results, and spread rapidly by means of stolons to form a dense sward.

Among legumes recently introduced, *Trifolium usambarense*, which is a local annual clover, and *Desmodium uncinatum*, a semi-prostrate perennial of South American origin, produced abundant growth and also seeded well.

In summing up the work done in the nursery, it is apparent that material with good vegetative characteristics is not hard to find, in fact it is often abundant, but the chief difficulty is to find good seeding qualities associated with it. This does not take long to ascertain when once sufficient material has been multiplied up, and the next task is generally to assess its persistence or otherwise under grazing conditions. It is the last factor which finally eliminates most of the material which is otherwise regarded as promising.

(2) Species for Leys

It has become much clearer as a result of the last season's work which our most useful ley species are. In the high rainfall mixed farming areas from 6,000 to 8,000 ft., Rhodes grass, Molasses grass and Nandi *Setaria* are outstanding. The latter has given good results as high as 8,600 ft. at Ainabkoi. From 8,000 to 9,000 ft., Cocksfoot, Perennial Ryegrass, Italian Ryegrass and Brome grass (*Bromus unioloides*) give good results. Of these last-mentioned four, Perennial Ryegrass has the disadvantage that it does not seed well in Kenya. The others, however, are satisfactory in this respect.

It seems from trials that Kenya White Clover, *Trifolium semipilosum*, may become a suitable companion legume to Rhodes and Molasses grass and Nandi *Setaria*, as it has given a most satisfactory performance during the past season. In the coming season it will be included in some leys sown down on the Grassland Station and also in some leys on two neighbouring agricultural stations and in co-operative experiments in the district in order to test it thoroughly under a variety of conditions.

Other legumes which have given good results during the past season are the two annuals, *Medicago denticulata* and *Trifolium rueppellianum*, the latter an indigenous annual red clover. *M. denticulata* has given a seed yield at the rate of over 1,100 lb. per acre from a quarter-acre plot, while the annual red clover has produced green material at the rate of over 20 tons per acre from two small plots. This clover species grows well under dry land conditions and also on wet or waterlogged soils, while the *Medicago*, called Burr Medic, may be useful in drier areas where *T. rueppellianum* will not thrive.

A preliminary trial at Kitale of annual legumes cut for hay or silage has produced the yields shown below. The first and third species grow well on soils of seasonal swamps (vleis) and have a special value for that purpose.

Table II

Species	Tons per acre green yield mean of 2 plots
Trifolium rueppellianum ..	21·0
Trifolium tembense	18·5
Trifolium steudneri	16·8
Antopetitia abyssinica	11·0
Crotalaria incana	9·6
Medicago denticulata	8·8
Crotalaria intermedia	8·3
Melilotis officinalis	6·5

During the past few years, various field-scale trials have been undertaken to compare the merits of various grasses and legumes as ley pasture species.

An experiment started in 1952 compared the three following mixtures, and the figures given below show the seeding rates in lb. per acre:—

(1) Guinea grass, 10 lb.; Signal grass (*Brachiaria brizantha*), 10 lb.; and Alyce clover (*Alysicarpus glumaceus*), 4 lb.

(2) Rhodes grass, 5 lb.; Nandi *Setaria*, 10 lb.; Stylo (*Stylosanthes gracilis*), 4 lb.; and *Dolichos falcatus*, 2 lb.

(3) Molasses grass, 10 lb.; Signal grass, 10 lb.; Lucerne, 5 lb.; and Alyce clover, 2 lb.

The mixtures were grazed by cattle on and off during the season. In the first mixture, the Guinea grass and Signal grass both did well, the latter persisting rather better. Alyce clover is poor and only odd plants remain.

In the second mixture, both the Rhodes and Nandi *Setaria* are persisting in their original proportions, while the two legumes, Stylo and *Dolichos*, are still there, but are not blending well with the grasses.

In the third one, the Molasses and Signal grasses are persisting, though the Molasses is patchy in places. The two grass species have not mixed well. The Alyce clover has almost gone. At the time this trial was put down, no seed of Kenya white clover was available, otherwise it would have been included in the trial.

In another field-scale trial, put down in 1953, the following species, sown without clover, were compared under various systems of grazing management, and their order of merit as regards production was:—

(1) Guinea grass, 38 tons per acre; (2) Nandi *Setaria*, 38 tons per acre; (3) Molasses grass, 31 tons per acre; (4) Rhodes grass, 31 tons per acre; (5) *Beckeropsis uniseta*, 25 tons per acre; and (6) *Paspalum dilatatum*, 14 tons per acre.

It is noteworthy that the first two species seem to have given a better performance than Rhodes and Molasses grasses, and for that reason they are worth special attention. Nandi *Setaria* is being brought into wider use, while the more extensive use of Guinea grass depends on sufficient progress being made in its establishment from seed. Both these species also tend to be green later into the dry season than Rhodes and Molasses grasses, *Paspalum dilatatum* is outstanding for greenness in the dry season, but its yield is not good.

Dry-Season Leys

The table below shows the comparative yields, from small plot experiments, of the various grasses which are suitable for cultivation in rows for wet-season silage or grazing, and particularly for dry-season grazing, when they provide green material. Elephant grass and *Setaria* species are the best, the highest yield shown being 38 tons of green matter per acre. The quality of such grasses on their own without legumes, however, is often poor and not much above mere maintenance.

So far, Elephant grass has been the main grass used for dry-season leys. In one field trial, this species gave the following production:—

Late January, 1954: 5.2 tons of green material available per acre.
Late November, 1954: 7.7. tons of green material available per acre.
} dry season.

The amount available during the rains was 14.2 tons per acre.

TABLE III

Species	Tons per acre green yield mean of 2 plots
Elephant grass ex Cameroons..	38·2
Setaria splendida—K.53678 ..	28·9
Kazungulu *Setaria*—K.52405	28·0
Hyparrhenia hirta—K.50105 ..	27·0
Setaria splendida—K.53763 ..	25·4
Beckeropsis uniseta	24·5
Perrenial Kavirondo Sorghum	20·3
Setaria splendida—K.51130 ..	17·9
Setaria splendida—K.51128 ..	16·0
Cenchrus ciliaris—K.5148 ..	15·8
Nandi *Setaria*	15·2
Sorghum verticilliflorum ..	14·2
Sorghum sp. ex Magadi ..	12·9
Setaria splendida—K.51131 ..	9·2
Brachiaria brizantha—K.52318	6·8
Hyparrhenia hirta—K.50192 ..	6·0

Guinea grass varieties have shown up well in small trials, and are being tested for pasture purposes in both the wet and the dry seasons.

The following table shows a comparison of Guinea grass varieties: —

TABLE IV

Type	Green yield in tons per acre mean of 2 plots	Visual estimation of quality
GROUP A—		
Rangwe River	16·2	Good
Malaba..	13·6	Very good
Mackinnon Road	13·5	Very good
Lilongwe	10·9	Very good
GROUP B—		
Sigor hairless	12·6	Good
Chepararia	12·6	Good
Wei Wei River	10·8	Fair
Gori River	7·4	Fair
P. maximum var. trichoglume	7·2	Good
Likoni	5·7	Fair
Sigor hairy	4·4	Poor

NOTE.—There is a difference in planting dates between groups A and B, and they are not therefore strictly comparable.

The advantage of Guinea grass is that it stays green later into the dry season than Rhodes or Molasses grasses and thus provides green grass at a time when it is scarce.

Lucerne

Considerable attention is being given to this species. A collection of 72 varieties from warm and temperate climates all over the world, shows a wide range of types varying from large upright plants to low prostrate types. A matter of importance is to try to find varieties resistant to leaf spot, which during the rains causes discolouration and finally defoliation of plants. So far no variety has shown itself to be completely resistant, but some are much better than others.

The varieties Booborowie and Hairy Peruvian seem to be more productive that most others. The collection is being enlarged further to help us find the most suitable variety obtainable for Kenya conditions.

Lucerne has given good results as a legume in the sward with Tall Fescue at some of the higher altitudes (7,000 to 8,000 ft.). There is little doubt that when better varieties have been selected for use, and more has been learnt about its nutrition needs and its requirements for effective nodulation, it will be a herbage plant or crop of even more value than it is at present. Useful progress is being made.

Co-operative Experiments

These experiments are carried out by a member of the staff on selected farms in the Trans Nzoia and Uasin Gishu districts, with a view to finding suitable ley species for altitudes, soil types and climates different to those at Kitale and Molo. The results of several years' work have been most satisfactory, as indicated at the beginning of this section. Some of the current experiments are described below.

Kipkabus, 7,600 *ft.*—A simple grazing grid was sown with the three grass species in wide parallel strips of half an acre each. These were Rhodes and Molasses grasses and Nandi *Setaria.* Strips of the five following legumes were sown across the grass strips: *Stylosanthes gracilis,* Alyce clover, Kenya white clover (*Trifolium semipilosum*), *Crotalaria incana,* and *Trifolium rueppellianum.* The grasses all established and performed well, and of the legumes two of the clover species were outstanding, namely Kenya white clover and the annual purple clover (*T. rueppellianum*). The latter was strong enough in its growth to suppress the Molasses grass to some extent.

Ainabkoi, 8,600 *ft.*—Perennial and Italian Ryegrasses and Cocksfoot were sown here with a companion grazing crop of oats and Serradella (*Ornithopus sativus*), and their growth and performance under grazing was most satisfactory. *Bromus unioloides* is also promising as a short rotation grass or even as a grazing companion species in the early stages of establishment. Its duration is frequently about two years, but is more than this under good fertility and management.

Eldoret, 7,000 *ft.*—A trial was carried out to ascertain whether grazing legumes could be successfully undersown in wheat for grazing off after the wheat harvest. The legumes were *Crotalaria incana,* a tall productive annual, *C. intermedia,* a smaller and slower plant, and sweet blue lupins. The wheat produced 7 bags (of 200 lb. each) per acre, and the *Crotalaria* species produced good growth. The wheat stubble, however, was left too long by the combine for the cattle to be able to graze it down successfully.

(3) Ley Establishment

Different methods of establishing leys have been tried, and all these have been fairly successful at various times. There is often a difference, however, in their efficiency. Up to date the methods have been concerned with the establishment of a pure stand consisting of one grass seed only with no legumes. The methods used have been:—

(*a*) Broadcasting with a seed-barrow, or a fiddle, or by hand.

(*b*) Drilling, using a special small seeds drill, or mixing the grass seed with superphosphates and sowing through the fertilizer box of the combine drill.

This last method is regarded as the most efficient, and is easy for farmers to use.

The grass seeds are either sown—

(*a*) direct, i.e. alone; or

(*b*) under maize or other grain cereal such as wheat at the higher altitudes; or

(*c*) with oats or sweet lupins as a grazing companion crop.

Of these, sowing alone or with a grazing companion crop seems to be the best.

The following experiments illustrate these methods:—

(i) An observation trial at Kitale was sown to compare leys established by direct seeding versus sowing with an oat companion grazing crop. The total herbage yield of oats plus grass was about 15 tons per acre compared with about 3 tons per acre from the grass sown alone. The latter, however, gave a better and more vigorous stand of grass by the end of the first season.

(ii) A preliminary experiment on the establishment of Nandi *Setaria* has shown that a cover crop of sweet blue lupins sown with adequate phosphate and a good bacterial inoculant may give an increase in grass production equal to that obtained by about 2 cwt. per acre of sulphate of ammonia. The effect of the lupins was most noticeable, both in colour and growth rate of the grass, and the extra production obtained was easily observable. This line of investigation is being carried on, as it seems a most useful one.

In the Co-operative Experiments programme, the following experiments were carried out on various farms:—

(i) Establishment in seasonal swamps, Topi Wallop, near Kitale. This land is waterlogged and partly under water during the rains, but dries out during the dry season. There is a vast area of this kind of land in the Colony, and the use of suitable species would enable much of it to be utilized for dry-season grazing purposes. Such land, however, needs to be managed with special care, to avoid damaging its water-holding capacity.

A two-acre trial was put down to test the merits of sowing on the flat, compared with land put up into wide ridges about 6 ft. wide and 12 in. high. On half of each area the seed was broadcast, and on the other half drilled in with the fertilizers. Double supers and sulphate of ammonia at 1½ cwt. per acre were used in combinations nil, N, P and NP. The species used were Nandi *Setaria*, Molasses and Rhodes grasses, *Paspalum dilatatum* and *Beckeropsis uniseta*.

The two main problems to contend with in establishing the seeds were waterlogging and weeds.

The results showed that sowing in drills with fertilizer on the wide low ridges was the best. Spraying with Agroxone 3 was satisfactory in controlling weeds, and the best species by far were Nandi *Setaria* and *Paspalum dilatatum*.

(ii) Eldoret, 7,000 ft. Ley establishment trial.—Four grass species were compared, in combination with four different legumes, under three different methods of establishment. These were, respectively, Nandi *Setaria* and Rhodes, Molasses and Guinea grasses; Alyce clover, Stylo, Burr Medic (*Medicago denticulata*) and Kenya white clover. They were (*a*) sown alone, (*b*) undersown to a wheat crop, and (*c*) sown with a companion grazing crop of oats. One cwt. per acre of double supers was used throughout, and oats sown at 40 lb. and wheat at 68 lb. per acre.

The result was that sowing alone gave much the best establishment, while the grasses undersown in wheat also did fairly well, while those with oats were poor as the latter unfortunately were allowed to grow away too much. The *Setaria*, Rhodes and Molasses grasses all did well in the sown alone and wheat treatments, but the Guinea grass was not a success, due to unsatisfactory germination. Among legumes, the Stylo and Alyce clover were unsuccessful, while the Kenya white clover and Burr Medic were a striking success.

(iii) Kipkabus, 7,000 ft. Establishment trial.—Five grasses were sown in wide strips and three legumes were broadcast across them. They were, as above, (*a*) sown alone, (*b*) undersown in a wheat crop, and (*c*) sown with a companion grazing crop of oats. 200 lb. per acre of soda phosphate was drilled with the grass seed through the fertilizer box of the drill. The result was that the species sown alone gave the best establishment, those with oats were retarded, and those under wheat were poor.

(iv) Lumbwa, 7,200 ft. Nyanza Province establishment trial.—The treatments in this trial were (*a*) grasses and lucerne in alternate rows sown with oats for grain, (*b*) as in (*a*), with the oats as a grazing companion crop, and (*c*) grasses and legumes sown alone.

In this trial the first treatment (*a*) gave the best results, which is perhaps accounted for by the weedy nature of the ground, the weeds being almost entirely suppressed by the oats. The grasses which did best were Rhodes, Molasses, Nandi *Setaria* and Kikuyu, the latter planted by means of runners.

(4) Management of Leys

A field-scale trial was carried out to ascertain which factors increased the output from Elephant grass, when used for silage cuts in the rains and for grazing off in the dry season. The treatments compared were (*a*) rows 3 ft. and 7 ft. apart, (*b*) sown with and without a bulky perennial legume, (*c*) the effect of sulphate of ammonia, (*d*) clean cultivation and nil, and (*e*) the effect of farmyard manure.

The addition of nitrogen, of farmyard manure and clean cultivation all brought about considerable increases in yield. The other factors had shown little effect up to date.

Average annual yields of green matter per acre were:—

Treatment		Control	Increase
	tons	*tons*	*tons*
Sulphate of ammonia (4 cwt.)	19·5	12·1	7·4
Farmyard manure (10 tons)	13·9	10·7	3·2
Clean cultivation between rows	29·5	23·3	6·2

The level of yields are lower than would be expected. This is because it was not a stand newly established for the experiment, but was already two years old.

Dry-season grazings were obtainable in this experiment in late January and late November in the second harvest year of this experiment.

(5) Management of Natural Grassland

An experiment has just been completed on the fertilizer, cultivation and reseeding treatment of rough natural grassland at Kitale. The intention was to try to improve the nutritive quality and botanical composition by means of these treatments. Sulphate of ammonia and double supers were tried singly and in combination. The cultivations comprised disc and spike harrowing. The grasses used were Signal, Guinea, Molasses and Star grasses and Nandi *Setaria*, and the legumes were Lucerne, Stylo, Kenya white clover, Alyce clover, *Glycine* and *Dolichos falcatus*. The herbage was subjected to frequent grazing over the three seasons of the experiment.

The results were disappointing. Cultivation and fertilizers helped slightly, and Molasses grass was rather better than the other grasses, but all were poor, i.e. showed very low establishment. *Dolichos falcatus*, a small twiner, Stylo and *Glycine* showed better establishment and persistence than the others.

It is not considered that this experiment shows that such improvement cannot be carried out. Since this was started, much has been learnt about species, implements and technique. It is thought likely that more satisfactory results might be

obtained if (*a*) the natural sward was heavily grazed at the end of the previous season, and the beginning of the season in which the experiment was started, in order to weaken the taller grasses, (*b*) the sward were to be closely mown before starting operations, (*c*) the legume seeds, e.g. Kenya white clover, properly inoculated, were to be forcibly drilled into the ground, with superphosphates, and the stoloniferous and other grasses also drilled in with a nitrogenous fertilizer (a suitable drill is now available for such work), (d) the mower was used periodically to keep down tall grasses while the new ones were establishing.

An experiment on these lines is worth carrying out when suitable equipment is available. If clover and Rhodes and Star grasses can be introduced by this means, the quality of rough grazing would be improved considerably.

(6) Fertilizers and Manures

Considerable work has been done on these lines up to date. The report of the Highland Fertilizer Scheme gives much information, and a number of papers have been published on the subject by the Pasture Research Chemist. The general trend is that leys and natural pastures respond to nitrogen and phosphate, but rarely to lime or potash.

The present trend is to try various combinations of the main fertilizers on high-yielding herbage plants, on grass-legume mixtures and on legumes such as lucerne and Kenya white clover.

(*a*) An experiment with Elephant grass and *Dolichos* Kilima Kiu in mixed rows, was put down in a 2^5 factorial design, with all combinations provided by the presence and absence of the following treatments: lime, $2\frac{1}{2}$ tons; double supers, $1\frac{1}{2}$ cwt.; muriate of potash, 2 cwt.; and sulphate of ammonia, $1\frac{1}{2}$ cwt. per acre. The fifth treatment was lupins dug in for green manure during the rains. A full analysis of the results is not yet available and therefore significance levels cannot be stated, but the responses so far in tons of green material per acre for the main treatments are as follows: Nitrogen, from 5.3 to 6.3 tons; phosphate, from 4.6 to 7.0 tons; potash, 6.0 to 5.5 tons (decrease); lime, 5.7 to 5.9 tons; and green manure, 5.5 to 6.1 tons per acre.

(*b*) Fertilizer experiments with lucerne.—This was also planted in a 2^5 factorial design, with all combinations provided by the presence and absence of the following treatments: Sulphate of ammonia, $1\frac{1}{2}$ cwt.; double supers, 2 cwt.; muriate of potash, 2 cwt.; lime, 4 tons; and cattle manure at 10 tons per acre. Significant responses were obtained from cattle manure, $P = 0.01$, and from potash at $P = 0.05$. There was a small response to phosphate, which, however, was not significant.

(*c*) A preliminary fertilizer experiment on Kenya white clover was laid on in small plots in a 2^5 factorial design, with all combinations provided by the presence and absence of the following treatments: Sulphate of ammonia, 1 cwt.; double supers, 2 cwt.; muriate of potash, 2 cwt.; lime, 10 cwt.; and cattle manure at 5 tons per acre. The response to the latter was significant, but the small response to phosphate did not attain statistical significance.

(*d*) Effect of fertilizers on natural grassland.—Various treatments and combinations using nitrogen and phosphate were applied in grassland adjacent to some seasonally wet or waterlogged land. The best responses were obtained from a combination of 2 cwt. sulphate of ammonia and 2 cwt. double supers per acre, which gave a yield of 24 tons per acre, an increase of nearly 100 per cent over the control.

(7) Inoculation and Nodulation of Legumes

A series of observation plots and experiments were put down to ascertain whether:—

(*a*) Inoculation of legumes has any effects on growth and production.

(*b*) Different makes of inoculant vary in their efficiency.

(*c*) Fertilizers have any effect on inoculation and nodulation.

(*d*) Trace elements effect nodulation.

(*e*) Nitrogen fixation occurs in legumes.

Twenty-five different pasture and other legumes were used in the experiments. A large number of *Trifolium* species were included, both indigenous and exotic, and also lucerne, Burr Medic, various lupins, Alyce clover and cowpeas.

In harvesting the experiments, large numbers of plants were carefully dug up after soaking the soil with water, and the soil was then slowly washed off in a basin. Plants with nodules were then counted and weighed green, and also those without nodules. The mean weight of a nodulated and an unnodulated plant was then compared for each species under the various treatments. As the experiments are only exploratory at this stage, the results are briefly summarized:—

(*a*) Inoculation does seem to result in better growth in a number of species. In the following ones, a statistically significant increase in weight was obtained when nodulated plants were compared with unnodulated ones: Lucerne, Bitter Lupins, *Teramnus labialis, Trifolium semipilosum, Alysicarpus glumaceus,* Subterranean Clover and *Trifolium usambarense.*

(*b*) Different manufacturers' strains appear to differ in efficiency. Although significant differences were not obtained, it is considered that they probably would be, with improved field techniques.

(*c*) Phosphate in the form of double superphosphates at 1 cwt. per acre frequently produces marked improvements in nodulation and growth.

(*d*) Nodulation takes place without the addition of trace elements, and application of these does not seem to increase nodulation at the concentrations used. It may, however, influence it at other concentrations.

(8) Seed Production

A number of experiments are in progress on seed production of our more important grasses. Results to date are summarized below.

(*a*) *Rhodes Grass*

A 3^3 factorial design was laid down, with all combinations provided by the following three factors at the levels indicated: (i) sulphate of ammonia at 0, 1 and 3 cwt., (ii) double supers at 0, $\frac{3}{4}$ and $1\frac{1}{2}$ cwt. per acre, and (iii) row spacings between the rows of 3, 4 and 5 ft. A statistical analysis is not yet available, but the general trends are shown in the two-way table below. Briefly, the trend is that the wider 5 ft. spacings have given better yields than the close ones at 3 and 4 ft. in the first harvest year, while increasing the applications of phosphate has increased the seed yield. The nitrogen response so far seems to be less consistent, but the higher rate gives an increased yield compared with the lower and the nil treatments. At the 4-ft. spacing, however, increasing rates of nitrogen gave increased yields.

TABLE VI

Treatment Yields in lb. per acre (3-*way table*)

	S_1			Totals	S_2			Totals
	N_0	N_1	N_2		N_0	N_1	N_2	
P_0 ..	194·7	192·9	225·0	612·6	347·8	206·3	294·9	939·0
P_1 ..	190·9	190·9	457·5	839·3	276·0	234·4	361·1	871·5
P_2 ..	378·2	242·0	334·6	954·8	272·2	423·4	470·8	1166·4
TOTALS	763·8	625·8	1017·1		896·0	954·1	1126·8	

	S_3			Totals
	N_0	N_1	N_2	
P_0 ..	266·6	255·2	457·6	979·4
P_1 ..	349·8	398·9	393·3	1142·0
P_2 ..	410·3	295·0	412·1	1117·4
TOTALS ..	1026·7	949·1	1263·0	

Yields in lb./acre (2-*way table*)

	P_0	P_1	P_2	Totals
S_1 ..	194·7	190·9	378·2	763·8
S_2 ..	347·8	276·0	272·2	896·0
S_3 ..	266·6	349·8	410·3	1026·7

	N_0	N_1	N_2	Totals
P_0 ..	809·1	744·4	977·5	2531·0
P_1 ..	816·7	824·2	1211·9	2852·8
P_2 ..	1060·7	960·4	1217·5	3238·6

	S_1	S_2	S_3	Totals
N_0 ..	194·7	347·8	266·6	809·1
N_1 ..	192·9	296·3	255·2	744·4
N_2 ..	225·0	294·9	457·6	977·5

(*b*) *The Effect of Fertilizers on Rhodes Grass Seed Production*

This was planted in a 2^5 factorial design, with all combinations provided by the presence and absence of the following treatments: sulphate of ammonia, 4 cwt.; double supers, $\frac{3}{4}$ cwt.; muriate of potash, 2 cwt.; and lime, $2\frac{1}{2}$ cwt. per acre, and the fifth treatment being a comparison between broadcasting and drilling in 3-ft. rows.

A full statistical analysis is not yet available, but the main effects are shown in Table VII below.

TABLE VII

Treatment	Control	Difference
N. 145 lb. per acre	132 lb. per acre	Plus 13
P. 156 lb. per acre	121 lb. per acre	Plus 35
K. 130 lb. per acre	148 lb. per acre	Minus 18
Lime 136 lb. per acre	142 lb. per acre	Minus 6

Nitrogen and particularly phosphate seem to give a positive response while potash and lime appear to be of no value at this stage.

(*c*) *Nandi Setaria—Effect of Fertilizers and Method of Sowing*

This experiment is also in the form of a 2^5 factorial design, with the various combinations formed by the presence and absence of the same treatments as in the Rhodes grass experiment above, with the same rates of application. The results have not yet been fully analysed, but the general trends are shown in the following table: —

TABLE VIII

Treatment	Control	Difference
N. 220 lb. per acre	.. 196 lb. per acre	Plus 24
P 207 lb. per acre	.. 209 lb. per acre	Minus 2
K. 212 lb. per acre	.. 204 lb. per acre	Plus 8
Lime 206 lb. per acre	.. 210 lb. per acre	Minus 4
Broadcast 176 lb. per acre	Rows 240 lb. per acre	Plus 64 in favour of rows

The biggest responses are to row cultivation and to nitrogen. It is probable that a phosphate response will show up in the next season. The effects of lime and potash may be more discernible after another two seasons.

(9) EXPERIMENTAL TECHNIQUE

A uniformity trial was put down on a typical piece of land on the station to investigate soil differences, fertility drifts and, in particular, optimum plot sizes for experimental work involving grass plots.

The species used was Guinea grass (*Panicum maximum* var. *trichoglume*), the thin-stemmed variety. This was planted 3 ft. square on a plot 40 × 80 yards, was the largest size that could be fitted into the land available. One year was allowed for full establishment, and three cuts were made during the 1954 season. The advantage of a grass compared to a cereal crop is: (*a*) that it does not suffer in the same way from theft or bird damage, (*b*) there is practically no effect due to disease as in maize, thus giving more reliable results, and (*c*) the yield figure consists of the total of several harvests obtained during the year, and may thus even out experimental error to some extent.

In order to avoid any differences due to wash, the whole plot was ridged with crossbars, the ridges running along the plant rows. All rain was therefore absorbed where it fell. The size of plot harvested was 1 × 4 yards. The detailed results are not yet available, but it is apparent from the yields obtained that fertility differences between some plots are substantial, and that a fertility drift also exists. The results will give a useful guide on the problem of the best plot size to use on the station.

(10) Seed Multiplication

A considerable amount of time and labour is devoted to this work, which is of great importance in supplying seed of promising species for experimental work on the station, for co-operative experiments, and for work on agricultural experiment stations.

(*a*) Nzoia Rhodes grass. There are about 40 acres of this on the Eldoret Experiment Station. Some of it is used in the early season for grazing, to fit in with farm requirements, but its main purpose is production of pure seed of the Nzoia strain.

(*b*) On the Grassland Station, Kitale, there are altogether 43 acres under seed production, which includes 19 species or varieties of grasses and 37 of various legumes. The most important of these are:—

Nandi Setaria, 11 acres.—Eight acres were put down in 1954. Plots in their first harvest year gave 180 lb. seed per acre with light fertilizer dressings. Seed was harvested by means of the Allis Chalmers combine harvester, which works well with it.

Kenya white clover, 5⅓ acres.—The plot of 0.4 acre established in 1953 produced seed at the rate of 700 lb. per acre, which was harvested by hand. It was threshed with the Allis Chalmers combine harvester. Five acres were established this year, 1954, to provide adequate seed for future trials and experiments.

Alyce clover (*Alysicarpus glumaceus*).—A 4-acre plot of this yielded 50 lb. of seed per acre. It does not compare with Kenya white clover as a pasture legume.

Annual red clover (*Trifolium rueppellianum*).—A ¼-acre plot produced seed at the rate of 290 lb. per acre. This productive species also produced green matter at the rate of 21 tons per acre (*see* Table II). It will therefore be multiplied up further for experimental work and field-scale trials.

Cherangani clover (*Trifolium cheranganiense*).—This is another perennial indigenous species of clover, but does not compare well with Kenya white clover. It is less productive and only produced seed at the rate of 92 lb. per acre.

Burr Medic (*Medicago denticulata*).—This has yielded exceptionally well this season from a ¼-acre plot at the rate of over 1,100 lb. per acre.

It will be multiplied further and tried out as a pasture legume in the drier or less fertile areas where Kenya white clover is less satisfactory. The main drawback to this species is the difficulty of harvesting its burred seeds, which are shed on the ground.

Lotononis bainesii.—This creeping perennial, which comes from the Transvaal in South Africa, has performed remarkably well here. It has particularly long, leafy stolons which rapidly spread and cover the ground. It flowers and seeds freely. Apart from possible value in pastures it may possibly be useful as a cover in some plantation crops.

Beckeropsis uniseta.—This is a tall, slightly coarse species suitable for pasture if kept short, but may have a special use in dry-season grazing leys owing to its deep-rooted habit and greenness in the dry weather. One of its recommendations is its easy establishment from seed and abundant seed production.

Much work is being done to find ways and means of obtaining cleaner seed of higher germinating capacity. At present we are using more or less "wild" species which have not yet been greatly selected or improved. Selection work and general improvement in technique as we go along should do a lot to improve the quality of our herbage plants and their seeds.

Report of the Pasture Research Chemist

Lucerne

The study on lucerne, referred to in the report for 1953, was completed. The 1954 work confirmed that at its early flowering stage of growth, Provence lucerne leaf provides more dry matter than its stem, it is much richer in crude protein and calcium, and it is less fibrous. The digestibility of the crude protein in both leaf and stem, as determined by the "in vitro" method of Wedemeyer, is high (85–90 per cent). The ratio of true protein to crude protein in both leaf and stem is relatively low, being of the order 0.64–0.85 for the leaf and 0.41–0.86 for the stem. In the absence of further work, it is not proposed to comment further on these low ratios.

Oats

The composition of green oats for forage and ensilage was studied. The chemical composition and nutritive value of oat grain, straw, hay and the green crop cut at the milky stage of growth for ensilage can be found in most textbooks on livestock feeding. Similar information on young green oats grown for forage can rarely be found in the literature, presumably because it has not been common practice elsewhere to utilize the cereal in this way. It is a method, nevertheless, which is favoured in certain districts of Kenya, and for this reason, information requires to be extended to include its composition under grazing conditions.

The data shown in Table IX refer to oats grown on the South Kinangop, on the farm of Mr. J. F. Lipscomb. The crop was sampled late in January, 1954, after initial grazing had taken place, and again in mid-March, after it had been grazed by a dairy herd each afternoon over a period of several days.

These results show clearly that green forage oats are extremely rich in crude protein and its digestibility is very high, when judged by "in vitro" determinations using the method of Wedemeyer. The crop is also rich in oil, contains satisfactory amounts of lime and phosphoric oxide, and is not fibrous. In these early stages of growth, green forage oats are a concentrated food for livestock, supplying a starch equivalent value of about 70 and a protein equivalent value of approximately 24.

TABLE IX

The Composition of Oats with Advancing Maturity
(*Based on* 100 *per cent dry matter*)

	29th Jan., 1954 Once grazed 9–10 in. high	18th March, 1954 Frequently grazed 3–4 in. high
Ash	9·12	9·96
Crude Protein	30·21	34·12
Ether Extract	5·82	6·46
Crude Fibre	17·17	21·35
Carbohydrate	37·68	28·11
True Protein	24·60	27·09
Percentage digestibility of Crude Protein	92·40	79·90
Lime CaO	0·58	0·64
Phosphoric Oxide P_2O_5	0·71	0·97

As would be anticipated, the composition of green oats alters as the crop advances towards maturity, and the results presented in Table X illustrate the nature of the changes which occur. This cereal was again grown on Mr. Lipscomb's farm, when 75 lb. per acre was drilled with the legume Serradella in October, 1953. In a seed bed which received 200 lb. of guano per acre it will be seen that as the crop develops, there is a progressive decline in protein, oil and minerals. Concomitantly, there is a marked increase in carbohydrate, the crop becomes more fibrous and its protein less digestible.

In its earlier stages of growth, the green crop may be used for forage, as discussed already, alternatively, it may be used for ensilage and cut more than once for this purpose. S. J. Watson, however, has shown that although cutting earlier certainly improves the feeding value of the green cereal, its yield may then be so low that it is not worthwhile. In his view, oat ensilage is better made when the crop reaches the fodder stage, that is, when the grain is still soft and milky. Maximum yields of dry matter and of crude protein per acre are obtained at this stage of growth, and by virtue of a lactic acid type of fermentation which proceeds rapidly, a very attractive silage can be produced.

On the South Kinangop, the green cereal was cut as it approached the stage of growth advocated by Watson. Its composition about the time of cutting, on 12th February, compares favourably with data provided by Woodman for oats cut at the "milky" stage, but it is less fibrous. Crude protein values are similar, and clearly show that when the cereal is headed out, it cannot be expected to give a protein-rich silage. By the time the green crop was ready for cutting on Mr. Lipscomb's farm, its companion Serradella had reached the flowering stage of growth, and its composition prior to cutting is shown in the last column of Table X. The legume is rich in protein of high digestibility, contains a high proportion of lime, a respectable amount of phosphoric acid and it is not fibrous. It can be expected therefore to enhance the protein and mineral value of the mixed crop and contribute also to its yield of dry matter.

TABLE X

The Composition of Oats with Advancing Maturity

(*Based on* 100 *per cent dry matter*)

Date and Stage of Growth	Oats				Oats		Serradella
	Kenya				England*		Kenya
	12–12–53 12 in. high	7–1–54 18–24 in. high	29–1–54 Early flowering	12–2–54 Full flower	In flower	Milk stage	29–1–54 Early flowering
Ash	10·55	11·50	8·46	5·40	7·76	7·89	11·46
Crude Protein	35·28	20·24	9·05	8·13	8·19	9·39	24·36
Ether Extract	5·67	3·68	3·16	2·41	2·50	3·01	3·72
Crude Fibre	16·87	23·25	23·31	28·05	36·63	32·25	18·66
Carbohydrate	31·63	41·96	54·81	56·01	44·83	47·46	41·80
True Protein	n.d.	14·94	4·79	4·71	n.d.	n.d.	18·75
Per cent Digestibility of Crude Protein	n.d.	84·88	74·59	46·74	73·60	54·31	89·12
Lime CaO	0·61	0·48	0·42	0·40	n.d.	n.d.	1·69
Phosphoric Acid P_2O_5	0·68	0·56	0·33	0·35	n.d.	n.d.	0·55

*Woodman, H. E., 1948. Rations for Livestock. *Bull.* 48, *Min. Agric. and Fisheries.*

THE CRUDE FIBRE DETERMINATION

The method in current use for the determination of crude fibre in feedingstuffs is that set out in the Fertilizer and Feedingstuffs Regulations (1932) of the United Kingdom. It is essentially a modification of the method proposed by Henneberg in 1864, and is sometimes described as the Weende Method, in perpetuation of the place-name of the research station, near Gottingen, where Henneberg worked. The present method for determining crude fibre, in common with the original, is empirical, and neither method takes into account the effects of altitude and consequent lowered boiling points of acid and alkali.

Working at Nairobi, 5,700 ft., where acid and alkali boil at 94°C., the writer has shown that the amount of crude fibre in a feedingstuff decreases directly and proportionately with the logarithm of the time allowed for digestion, and that a boiling point of 45 minutes at 5,700 ft. will give results not significantly different from those obtained after boiling for 30 minutes at sea level. Similarly, results obtained after boiling at 5,700 ft., multiplied by a calculated "correction factor", will give values not significantly different from those obtained after boiling for 30 minutes at sea level.

Molo Grassland Research Station (9,000 ft.)

Progress at Molo during the year on experimental work has been most satisfactory. The station has, however, been much hampered by the absence of development funds for equipment and livestock, and for a house for the farm manager. Far more could have been achieved if the Pasture Research Officer had been able to devote his whole time to experimental work, instead of doing farm work as well.

(*a*) *Spraying Trials*

Work on the control of Spurrey (*Spergula arvensis*) in young leys by spraying has continued, and has confirmed last year's results. For perennial ryegrass, 4 pints per acre of Agroxone 3 is quite adequate for control, and can be put on at any stage of growth. Cocksfoot is more sensitive, however, to this rate of spray, and 4 pints per acre gave it a setback. More work is required to find the optimum rate

for Cocksfoot, which is more sensitive and also a slower grower. Cultivation methods, such as three discings of the Spurrey before sowing, can also be used, but this makes sowing and establishment of the young ley very late in the season. Spurrey is not the only weed to be contended with, but is one of the worst owing to its abundance, and rapidity and density of growth under Molo conditions. Unless suitably dealt with, it can smother the young grass seedlings entirely. The next problem is to find a way of introducing a legume into the sward. There are two local perennial clovers which might do, Kenya white clover, i.e. *Trifolium semipilosum* var. *kilimanjaricum*, and also Kenya purple clover, *Trifolium johnstonii*. Introduced species such as *Trifolium repens* and *Medicago lupulina* are also being tried out. The purple clover mentioned above seems to show some resistance to Agroxone 3 at 4 pints per acre, and further work will be carried out on this line.

The other possibility is to introduce the legume after the grass has been sown. The first season's results with this method do not seem to have been satisfactory up to date, but this cannot be regarded as conclusive yet.

A trial was also carried out on the spraying of oats undersown to perennial ryegrass, and a good establishment of the grass was obtained. In another trial, a high rate of seeding of oats was used, at 200 lb. per acre, and this suppressed weeds to about the same extent as spraying. The establishment of the ryegrass was satisfactory when the oats were cut for silage at a height of 2½ ft. Further work is needed, however, before one can be certain of the value of this method.

(*b*) *Nursery on Seasonally Waterlogged Ground*

An exploratory trial with liming was carried out on this ground, which becomes a swamp in the wet season. It was found that wheat, grasses (ryegrasses, Cocksfoot, Timothy, Fescue) and legumes (lucerne, red and white clovers and Medics) grew much better with an application of 4 tons of lime to the acre, and better still with 8 tons. In the absence of lime in this nursery, Italian ryegrass and Yorkshire Fog have given the best results.

(*c*) *Seed Production*

Experiments are in progress on seed production from Cocksfoot and perennial ryegrass. The latter has so far shown itself to be a shy seeder. Various combinations of nitrogen, phosphate, potash and lime are being tried. The best treatment so far has been the combination of phosphate and nitrogen with potash, but this can only be regarded as an indication at the present stage.

(*d*) *Lucerne*

A collection of lucerne varieties is being built up in order to be able to select from as wide a range as possible. An experiment was also carried out to ascertain which fertilizer treatments encourage nodulation in lucerne. The two treatments which gave the best results were the limed plots with 80–100 per cent of the plants nodulating well, and the phosphate plots with 20 per cent.

(*e*) *Sowing of Legumes in Last Year's Grass Leys*

Perennial ryegrass and Cocksfoot were established in close rows in 1953 by means of discing and spraying techniques, and this year lucerne, trefoil (*Medicago lupulina*) and Ladino clover seed were sown over them. On the unlimed plots there was no establishment, and a poor establishment only on the limed plots.

(*f*) *Short-Rotation Grasses*

Westernwolths ryegrass has given a particularly good performance during the year. Grazing started nine weeks after sowing and was resumed again after another three weeks and it did well during the season. Another two seasons should show what its potentialities are.

The best ley species for Molo in order of merit, in the light of present experience, seem to be perennial and Italian ryegrasses, Cocksfoot, and then probably Brome grass (*Bromus unioloides*) (formerly called *B. marginatus*). Tall Fescue seems to be rather coarse and fibrous in comparison with these. Italian ryegrass seems to last three to four years up at Molo and is a most useful grass. The use of *Phalaris* up here is still doubtful. A suitable legume has still to be selected from those available, and also a reliable means of establishing it. It is very apparent that ryegrass pastures up here become slightly thin and yellowish in their second year onwards compared with ryegrass-clover pastures in Europe, which are much healthier in appearance and more productive.

List of Publications, Reports and Broadcasts, 1954

(*a*) *Publications*

(1) A. V. Bogdan, "Bush Clearing and Grazing Trials at Kisokon, Kenya". *E.A. Agric. Journal,* Vol. XIX, No. 4, April, 1954, pp. 253–259.

(2) W. R. Birch, "Species for Leys in High-Altitude Areas". *Journal of the Royal Agricultural Society of Kenya,* No. 2, April, 1954.

(3) H. W. Dougall, "Fertilizer Experiments on Grassland in the Kenya Highlands". *E.A. Agric. Journal,* Vol. XIX, No. 3, January, 1954, pp. 171–178.

(4) H. W. Dougall, "The Chemical Composition of Three Weeds in the Kenya Highlands". *E.A. Agric. Journal,* Vol XIX, No. 3, January, 1954, pp. 152–3.

(5) H. W. Dougall, "Effects of Ammonium and Nitrate Nitrogen on a Temporary Molasses Grass Pasture". *E.A. Agric. Journal,* Vol. XIX, No. 4, April, 1954, pp. 261–2.

(6) H. W. Dougall, "Kikuyu Grass II—An Attempt to Improve a Worn-Out Pasture". *E.A. Agric. Journal,* Vol. XIX, No. 4, April, 1954, pp. 212–8.

(7) H. W. Dougall, "Some Fertilizer Aspects of Grassland Husbandry in the Kenya Highlands". *Journ. Brit. Grass. Soc.,* June, 1954.

(8) H. W. Dougall, "The Composition of Green Oats for Forage and Ensilage". *E.A. Agric. Journal,* Vol. XX, No. 2, October, 1954, pp. 118–9.

(9) L. R. N. Strange, "Species for Leys in Medium-Altitude Areas", *Journ. Royal Agric. Soc. of Kenya,* No. 2, April, 1954.

(10) L. R. N. Strange, "The Production and Handling of Herbage Seeds". *Journ. Royal Agric. Soc. of Kenya,* No. 3, July, 1954.

(11) L. R. N. Strange, "Ley Establishment at Medium Altitudes". *Journ. Royal Agric. Soc. of Kenya,* No. 4, November, 1954.

(*b*) *Reports*

E. D. Bumpus, "Report on a Visit to Research Stations in Uganda, 27th August-4th September, 1954".

(*c*) *Broadcast Talks*

(1) W. R. Birch, "Ley Establishment at High Altitudes".

(2) A. V. Bogdan, "Grass Burning".

(3) A. V. Bogdan, "Management of Natural Grassland".

(4) E. D. Bumpus, "The Work in Progress on Grassland Research".

(5) E. D. Bumpus, "Species for Leys".

(6) H. W. Dougall, "Fertilizers for Grassland".

(7) R. G. Poultney, "Lucerne".

(8) L. R. N. Strange, "Ley Establishment and Medium Altitudes".

(9) L. R. N. Strange, "Dry-Season Fodder and Grazing".

Acknowledgments

It is a pleasure to acknowledge the excellent work which has been done by all members of the staff during the past year, which has been a difficult one, with five members called up to the forces and others away on leave. A large programme of investigation has been successfully carried out, which could not have been done without a lot of extra time being willingly given by those concerned. I am very glad of this opportunity to be able to convey my warm appreciation to all the European and African members of the staff who have contributed to much to our work and achievements during the year.

E. D. BUMPUS,
Senior Pasture Research Officer.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (HORTICULTURE) FOR 1954

Introduction

Horticultural experimental work is carried out on temperate fruits and vegetables at Molo (8,300 ft.) and on tropical and sub-tropical fruits and vegetables at Matuga (150 ft.). Some work is also done at sub-stations at the Coffee Research Station, Ruiru (5,000 ft.), at Kitale (6,000 ft.), and on farms at various altitudes and under a variety of climatic conditions.

Temperate Fruit Trees at Molo

Apples.—Probably on account of unsuitable weather conditions at and after flowering time, the crop was generally rather poor this season. The Blenheim Orange crop was disappointing, despite the fact that spur thinning was done during the winter pruning and the set was good. The lack of shoot growth and poor development may well be due to inadequate nitrogen as, in an effort to control bitter pit, this part of the orchard was put down to a cover crop of Seradella and manure has not been given for several years. The variety King of Tomkins County tends to produce long, bare shoots, which break into growth only at the tips, to have few fruiting spurs and to bear light crops. Summer pruning, by cutting back all lateral and internal shoots to the ring of buds at the base of the shoots, has caused many dormant buds to break on the old wood and will probably increase the production of fruiting spurs.

Plums.—In order to try to improve fruit quality a chemical thinning trial was started on three trees of each of the following varieties: Shiro, Tazagine, Jardin's Early, Wilson, Methley, Watson's Cropper. One tree of each variety was sprayed with 2½ per cent capsine (D.N.O.C.) when in full flower, a second was sprayed four weeks after blossom fall with Planofix at a concentration of 30 parts per million of alpha napthalene-acetic acid, and the third tree of each variety was left as a control. The treatments did not effect any significant increase in fruit weight. Thinning of branches and fruiting wood during winter pruning, which was also tried, did appear to give larger fruits, although no records of fruit weight were kept. Further trials will be made next season.

Peaches.—The three varieties introduced from Southern California, described in the 1948 Annual Report, bore their first fruit this year, but at the time of writing only one, Ventura, has ripened its fruit. Ventura, which ripens at Molo at the end of January or beginning of February, has fruit of fair size and an attractive appearance, the skin being yellow with a deep red blush. Flavour is most disappointing. The quality of peaches grown at Molo is never high, and moreover, a variety cannot be judged on the first fruit from young trees, but, although it may produce fruits of better flavour in a warmer climate, the quality of Ventura seems likely to be rather inferior.

Berry Fruits

Youngberries.—At Molo, old established youngberries, grown under basin irrigation twice a month and protected from bird damage by cages, yielded at the rate of 4,200 pounds per acre, which at a price of Sh. 2 to Sh. 3 per pound gives a very high return per acre. At the Coffee Research Station, Ruiru, plantings made in March, 1951, have cropped poorly so far, although the fruit produced has been of a large size and good flavour. Growth has been reduced by prolonged dormancy, due to the unsuitable climate at this altitude, and, although there has been some response to oil spraying, further trials are needed to find means of obtaining optimum results from this treatment.

South American Rubus Species.—Seed of three species of Rubus, indigenous to South America, was received from Dr. G. Darrow of the United States Department of Agriculture in 1952. To date, *Rubus Honduriensis* has made extremely vigorous self-supporting growth of up to 8 ft. in a year and the plants are just starting to flower for the first time. *R. shankii* which is vigorous and very thorny, has produced heavy crops of fruit which is dark red to black in colour when ripe, up to $\frac{1}{4}$-in. diameter and very sour. *R. glaucus* appears to be lacking in vigour and subject to frost damage.

Strawberries.—Material of the variety Melba at Molo, which had been looking unhappy for some time, was divided into two portions, one being intensively deflowered for three months and the other untreated. The former has started to make good growth again while the latter has continued to overbear and produce miserable fruit—a tendency common in Melba particularly if grown under irrigation when it bears fruit all the year round. Plants of the varieties Cambridge 448 (Cambridge Early Pine) and Cambridge 449, imported during 1950, deteriorated badly in 1954, possibly due to a virus infection, and the plants were lifted and burnt. As Cambridge Early Pine had previously given very promising results, a fresh importation of 5,000 plants was made this year with the intention of further propagation and distribution to growers, should the material prove satisfactory after a year's quarantine at Molo. The following further Cambridge varieties were imported in April, 1954: Cambridge Premier (276), Cambridge Regent (679), Cambridge Profusion (254), and Cambridge Favourite (442). Of these, only Cambridge Favourite shows any promise but it will require further testing before any recommendations about it can be made. Its fruit is of very large size fairly firm, well shaped and highly coloured but the flavour appears to be poor. It is probably resistant to leaf spot. Seed of the wild Chilean strawberry, *Fragaria chiloensis* was imported from South America in 1952 but, so far, the plants have not flowered.

Sub-Tropical Fruits under Irrigation at the Coffee Research Station, Ruiru

Citrus, figs, avocados, mangoes, cashew nuts and Mexican hawthorn are being grown with and without irrigation at the Coffee Research Station. During the 1953–54 season the rainfall was 36.65 in. and the irrigated trees received, in addition, 36 in. per acre of water applied to basins of approximately 16 sq. yards per tree. Girth measurements indicated that irrigation has not affected growth to the extent expected, but it has had a marked effect on the fruiting of those species which have started to bear. With one variety of banana, bunch weight was increased by $4\frac{3}{4}$ lb. by irrigation, which also cause 74 per cent of the plants to produce bunches by the end of the season as compared with only 38 per cent from the unirrigated plot. Figures for the fruit of Fuerte avocado and cashew nut are shown in the table below:—

TABLE I

	Irrigated		Not Irrigated	
	Av. No. of fruits per tree	Av. Wt. of fruit per tree	Av. No. of fruits per tree	Av. Wt. of fruit per tree
Fuerte Avodado	61·0	44·0 lb.	25·1	16·5 lb.
Cashew nut	173	22·5 ozs.	66	7·5 ozs.

Application of 14.3 in. of irrigation water to cape gooseberries treated as an annual crop, in addition to rainfall of 39.7 inches increased the yield per acre from 3,104 to 3,763 lb. and resulted in a greater proportion of the fruit being harvested early, but, as the fruit is likely to be used mainly for canning and as the yield increase is only moderate, it is unlikely that irrigation would prove profitable.

Citrus at the Coast

As good seedling orange trees are likely to be more suitable for African growers than budded trees, work in the Matuga nursery has been switched from the latter to the former. Seed is being obtained from selected, recorded sweet orange trees at the Coast, and from tangerines at Turbo. Germination of sweet orange seed has been low, averaging 50 per cent, and consequently a small trial was made to see whether 2, 4-D as phordene would improve germination, as this treatment has been found effective in California. Four lots of 200 seeds each were treated as follows: (*a*) left standing in a damp state overnight, sown the following day and watered at sowing with tap water. (*b*) left standing in a damp state overnight, sown the following day and watered at sowing with tap water containing 0.0075 parts per million of 2,4-D, (*c*) soaked overnight in tap water containing 0.0075 parts per million 2,4-D, sown the following day and watered at sowing with tap water. (*d*) as (*c*), but watered at sowing with tap water containing 0.0075 parts per million of 2,4-D. Lots (*b*) and (*d*) were subsequently watered three times with tap water containing 0.0075 parts per millian of 2,4-D. Germination figures are given in Table II and show a beneficial effect of 2,4-D on germination. This treatment did not appear to affect growth.

Table II

Lot	Per centage Germination	
	18th Oct.	27th Oct.
A	56	56
B	65	66
C	64	68
D	74	74

First or second crops of most of the varieties of citrus were harvested from budded trees in the orchard at Matuga this year. Meyer lemons have given three crops of excellent quality fruit during the year. Lisbon, Eureka and Villa Franca lemons have produced fruit with good quality flesh but of unattractive appearance owing to the skin being rough and warty. There is, however, some evidence that fruit appearance will improve as the trees grow older. The quality of the early crops of oranges, tangerines and grapefruit has been disappointing. All orange varieties have shown granulation, Washington Navel and Renmark Navel being the worst, with all fruits completely granulated, while Pineapple and Lue Gin Gong have only shown granulation at the stem end of the fruit. Poor quality and some degree of granulation, has also been found in all grapefruit varieties,

Foster being the least affected. Grapefruit trees are also showing signs of stem pitting. Observations of some citrus varieties are summarized in Table III: —

TABLE III

	Av. No. fruit/trees	Av. Weight lb./tree	Cropping	Quality
1. Mexican Lime ..	1,316	180	Feb.–Mar. July–Aug.	Excellent.
2. Pineapple orange ..	260	122	July	Good, slight granulation.
3. Valencia Late orange	190	135	September	Poor, very granulated.
4. Washington Navel orange.	110	91	June	Bad, 100 per cent granulation.
5. Lue Gim Gong ..	467	260	July–August	Good, slight granulation.
6. Foster Grapefruit..	44	29	September	Good, very slight granulation.
7. Meyer lemon ..	607	452	Mar.–Apr.–May, July–October	Excellent.
8. Eureka lemon ..	45	79	July–Dec.	Good, rough rind.

Observations of older orange and grapefruit trees in orchards at other places at the coast have shown granulation to be relatively slight or absent, even with varieties such as Washington Navel and Valencia Late, which have borne very badly granulated fruit on young trees at Matuga. Hence it seems likely that granulation will decrease as the trees mature. Fruit from seedling orange trees has shown little or no granulation but the condition has been found in seedling grapefruit.

Citrus bud mite, *Aceria sheldonii,* which was first identified in Kenya this year, is widespread on budded varieties at the coast but does not appear to have attacked seedling trees. Red spider, *Tetranychus* sp. and *Paratetranychus* sp., continues to be a serious pest, causing fruit discolouration which reduces the value of the fruit and is sometimes so severe as to render it unsaleable. A fair degree of control was obtained at Matuga by spraying with Alboleum, particularly during the dry season from January to April. Thrips, *Scirtothrips* sp., have not been of much consequence. There have been periodic attacks of aphis, *Toxoptera aurantii,* during growth flushes at Matuga but these have been controlled with a tobacco extract spray. Control of the leaf-eating larvæ of the Orange Dog Butterfly, *Papilio demodocus,* has been by hand picking. Soft green scale, *Coccus hesperidium,* has often attacked isolated trees badly but good control is obtained by three sprays of Alboleum at 10-day intervals. The disease *Alternaria citri* continued to be troublesome on rough lemon root stocks but Perenox spraying kept it under control so that stocks were in a healthy condition prior to budding in December.

Other Fruit Trees at the Coast

Two superior coast varieties of mango, Ngowe and Boribo, are being propagated for distribution. Both can be raised satisfactorily from seed since the seeds are polyembryonic and the weaker seedling from the sexual embryo can be eliminated. Attempts to propagate the apple mango by marcottage have so far been unsuccessful. Marcotting of litchis has been successful, about 80 per cent

of the treated shoots forming a considerable ball of roots in several months, but some difficulty has been experienced in hardening off the marcotts after removal from the parent tree.

Pineapples

(A) At the Coast

Fertilizers and Mulching.—A 2^1 factorial trial with nitrogen, phosphate, potash and mulch was started at Kilifi in March, 1952. The plants began flowering in 1953 and fruit was harvested early in 1954 but, owing to the poor season, the crop was very poor, the percentage of fruiting plants being low and some plots producing no fruit at all. There was an indication that nitrogen and phosphate together, and mulching, increased the crop, but no treatment had any effect on the mean size of the fruit. It was impossible to produce a can of slices from any one plot and fruit from each treatment was canned as segments. Colour, texture and flavour of canned fruit from the NPK plots appeared to be slightly better than that from other treatments.

A 4 x 3 x 2 x 2 factorial experiment, in two replicates, one under coconut shade and one in the open, was started at Kilifi in March, 1953, to compare all combinations of the following treatments: (*a*) nitrogen at 0, 1, 2 and 3 levels, (*b*) phosphate at 0, 1 and 2 levels; (*c*) potash *vs.* nil; (*d*) mulch *vs.* nil. No crop has yet been harvested from this trial but observations of growth indicate a beneficial effect of nitrogen and mulch while phosphate and potash in absence of nitrogen appear to have had an adverse effect. Growth and uniformity have been better in the shaded replicates than in the open.

In both the trials mentioned above the plots size is too small to permit of a sample for a canning test to be drawn from individual plots. In view of the apparent response to nitrogen and to mulch, a further trial was put down in March, 1954, with large plots in order to determine the effect on quality of canned fruit of four levels of nitrogen (0, 3, 6 and 12 lb. of sulphate of ammonia per 100 plants), combined with mulch *vs.* nil. This is a randomized block trial of four replicates, two being under coconut shade and two in the open. No fruit has yet been harvested, but the mulched plots with the highest rate of nitrogen have made the best growth.

(B) In the Thika/Ruiru Area

Fertilizers, Mulching and Trace Elements.—A 2^4 factorial trial was started at Karamaini Estate in December, 1951, to test the effect of the following treatments: (*a*) nitrogen as 2,000 lb. of sulphate of ammonia per acre *vs.* nil; (*b*) magnesium *vs.* nil; (*c*) iron *vs.* nil; (*d*) soil fumigation with Ethylene dibromide *vs.* nil. The sulphate of ammonia gave a large increase in the plant crop which was sufficient to pay for the cost of the fertilizer. The ratoon crop has not yet been harvested but a residual effect of the sulphate of ammonia is apparent in the growth and vigour of the plants. No other treatment has had any effect except the soil fumigation which, as it was unfortunately applied in an inappropriate manner, had an adverse effect.

A 4 x 3 x 2 x 2 factorial trial in two replicates was started at Karamaini Estate in April, 1953, to compare the following treatments: (*a*) nitrogen at 0, 3, 6 and 12 lb. of sulphate of ammonia per 100 plants; (*b*) phosphate at 0, 1 and 2 lb. of double superphosphate per 100 plants; (*c*) potash at 0 and 2 lb. of muriate of potash per 100 plants; (d) mulch *vs.* nil. The first crop was approaching maturity at the end of the year and the indications are that the highest level of nitrogen, when combined with superphosphate a potash or mulch, or with all three together, has had a more beneficial effect on plant growth and colour, than has nitrogen only. Mulch by itself has had a depressing effect on growth.

Two further trials started at Karamaini in April, 1953, have not yet been harvested and have shown no appreciable effect of treatments. The first compares three spacings combined with mulching *vs.* nil, and the second tests the application of copper and manganese and the use of soil fumigation.

Trials on "Vlei" and "Black Cotton" Soils.—Hitherto, pineapples have been almost exclusively grown on freely drained red soils in the Thika/Ruiru area but trials with this crop have now been started on the heavier soils with impeded drainage which are widely distributed in this area. At the Coffee Research Station a 2^3 trial was started in March, 1954, with the treatments: (*a*) nitrogen as 10 cwt. of sulphate of ammonia per acre *vs.* nil; (*b*) phosphate as 4 cwt. of double supers per acre *vs.* nil; (*c*) farmyard manure at 10 tons per acre *vs.* nil. The pineapples were planted on 24-ft. raised, cambered beds which have proved most effective in producing satisfactory conditions of drainage and soil tilth. The crop has made really excellent growth. A similar trial on black cotton soil, using 12-ft. cambered beds, was started at Kalimoni Estate in November, 1954, which tests the effect of mulching as well as that of nitrogen, phosphate and farmyard manure.

Artificial Induction of Flowering.—Work is in progress to investigate the possibility of controlling the time of flowering and fruiting by chemical sprays in order to spread the crop more evenly over a longer canning season and to avoid fruit production at unsuitable seasons of the year. A trial was begun at the Coffee Research Station in March, 1954, in which various concentrations of Planofix, Hortomone A, 2,4–D, acetylene, "Tomato Set", beta-indolyl-butyric acid and alpha-naphthalene acetic acid were applied as a mist spray. Alpha-naphthalene acetic acid proved the most effective material, and at the time of writing fruit has been harvested from 28 per cent of the plants receiving this treatment whereas no fruit has been harvested from the control plots. The least effective material was 2,4-D, which showed some evidence of inhibiting flowering. Two trials were conducted at Karamaini Estate, one starting in May, about three months before the time of natural flowering, and the other in September, which is when flowering would normaly be expected to occur. Unfortunately, fruiting records were not obtained from these trials but infloresence records taken three months after application of treatments are summarized in Table IV. By the end of December, fruit had been harvested from 98 per cent of the treated plants in the second trial whereas in the control plots fruit had only been obtained from 75 per cent of the plants:—

TABLE IV

Infloresence Results

Trial I	Concentrations Planofix in water	Percentage flowering	Trial II	Percentage flowering
Plot 1 ..	1 cc : 500 ccs	30·0	Plot 1 ..	90·0
Plot 2 ..	0·75 cc : 500 ccs ..	27·0	Plot 2 ..	100·0
Plot 3 ..	Control	Nil	Plot 3 ..	40·0
Plot 4 ..	0·5 cc : 500 ccs ..	23·0	Plot 4 ..	96·0
Plot 5 ..	0·25 cc : 500 ccs ..	22·0	Plot 5 ..	96·0

Root Studies.—In order to obtain information on the root range and habit of pineapples on the red soils, the roots of plants 14 months old and 3½ years old were washed out and examined. The roots of the younger plants were concentrated in the surface layer of the soil, being composed of a compact mat of roots to a depth of 3 in. and extending over a radius of 18 in. The older plants showed a similar root system but the thickness of the mat was greater and reached a depth of 6 in.

(C) In Other Areas

Exploratory trials have been started to test the possibility of growing pineapples in the Rongai, Kitale and Kisumu areas. A large part of Nyanza Province, particularly that lying at an altitude of 5,000 ft., is thought to be suitable for pineapple production, and, with the possibility of a cannery at Kisumu in mind, nine trials were planted within a radius of 50 miles of that town at varying altitudes and on different soil types. In some of the exploratory trials the effect of nitrogen and mulch is being tested and in the trial at Kitale it has been observed that sulphate of ammonia has had a beneficial effect on growth but mulch has had no effect.

Tomatoes

In view of the immediate possibility of obtaining large contracts for export of tomato purée, widespread trials with varieties suitable for pureé manufacture were begun in areas considered promising for this crop. The price to growers for fruit for purée manufacture is unlikely to exceed £12 per ton and it is, therefore, essential to minimize the cost of production by adopting cultural methods similar to Californian practice. In these trials a wide spacing of 6 ft. x 3 ft. or 7 ft. x 2½ ft. was adopted to allow of mechanical cultivation during the early stages of the crop, seed was sown direct in the field to eliminate the cost of transplanting, and no pruning or staking was done. Most of the trials were carried out in co-operation with growers. They were situated at Powey's farm, Subukia (6,700 ft.); Barret's farm, Nakuru (6,000 ft.); Turner's farm, Ol Punyata (5,600 ft.); the Horticultural Sub-station, Kitale (6,200 ft.); Bungoma Experimental Station (4,700 ft.); Irwin's farm, Hoey's Bridge (6,000 ft.); and Arnold's farm, Elgon (6,600 ft.) The trials at Subukia and Bungoma failed completely, that at Ol Punyata was only partly established and will not give reliable yield figures, and growth is very uneven in the one at Kitale. Each trial consisted of ten varieties selected from the following: TX.28.A (ex Australia), Tatinter (ex Australia), KY.1 (ex Australia), Bawley's Selection (ex Australia), San Marzano (ex Italy), Genovese (ex Italy), Strains 6, 7, and 8 (ex Germany), Break o' Day (ex America), Early Red (ex America), Early Baltimore (ex America), Homestead (ex America).

At the time of writing, harvesting has not been completed but some preliminary observations can be made. The direct sowing method gave excellent germination and very strong, stocky plants in all trials, but the 3-ft. spacing in the row appeared to be too wide. The most promising varieties appear to be, in order of merit, Early Red, Strain 8, Early Baltimore, Bawley's Selection, Homestead, Break o' Day. Owing to the susceptibility of tomatoes to blight, which occurs during the rainy season, it is essential to produce the crop during the dry season. The higher temperatures prevailing at this time of the year are also much more satisfactory for growth and cropping. It, therefore, seems evident that tomato-growing on a large scale for purée manufacture can only be undertaken successfully under irrigation. The Hoey's Bridge area provides ideal temperature conditions for successful tomato growing during the dry season and also has a considerable acreage which is potentially irrigable. This district has a past history of good tomato yields and Hoey's Bridge itself would be a suitable factory site, being situated on the railway and having a good water supply from Nzoia river.

A trial was begun at the Coffee Research Station in January, 1954, to test the effect of eelworm control by the use of D.D. as a soil fumigant and to compare the yield from pruned single cordon and unpruned plants. The rainfall of 24.8 in. which fell during the course of the trial was supplemented by 10 in. of irrigation, mostly given during the period of establishment of the crop after

transplanting. The results of the trial are summarized in Table V from which it will be seen that the eelworm control doubled the crop and that the unpruned plants gave higher yields than the pruned plants. The spacing for the pruned plants was 2 ft. x 2 ft. in double rows with 4 ft. between the double rows, while for the unpruned plants the spacing was 4 ft. x 4 ft. The yield figures given in the table represent marketable fruit only.

TABLE V

Yields per acre, tons

Variety	Treated		Untreated	
	Pruned	Unpruned	Pruned	Unpruned
Strain VII	4·9	6·3	2·9	2·3
Strain V	2·5	4·0	0·9	3·2
Strain IV	3·8	4·6	1·6	2·0
Mean	4·35		2·15	
Mean	Pruned: 2·77		Unpruned: 3·73	

Six varieties of tomato were compared in single plots at the Coffee Research Station, the planting distance being 4 ft. x 4 ft. and the plants being unpruned. The yields, given in Table VI, were influenced by rather poor soil conditions and by blight which developed as the plants came into bearing. Blight was more serious on San Marzano than the other varieties and consequently it did not reproduce the high yields, averaging 7.5 tons per acre, which it gave in the two previous trials.

TABLE VI

Variety	No. Fruits per lb.	Yield per acre
		tons
Bawley's Selection	3·6	6·7
Tatinter	3·3	4·8
TX.28.A 9 : 1 : 3	2·6	5·2
KY.1.	3·8	1·2
Amateur	7·7	0·7
San Marzano	16·4	0·3

Vegetables

Onions.—An observational trial was conducted at the Coffee Research Station during the short rains in 1953 with a variety Texas Grano to compare direct sowing with transplanting. The rainfall of 11.29 in. during the experiment was supplemented by 13.5 in. of irrigation applied to direct sown plots and 16 in. (10 in. before transplanting and 6 in. after transplanting) applied to the transplanted plots. The crop was free from diseases and, although thrips became troublesome in November, D.D.T. gave a fair control. The results, summarized in Table VII, show that transplanting gave 2.4 tons per acre more than direct sowing and also produced bigger bulbs.

TABLE VII

	Date sown or harvested	Harvesting period	Yield p.a.	MEAN WT. PER BULB		Per cent Grade I
				Grade I	Grade II	
			tons	*ounces*	*ounces*	
Direct sown	19/8	23/12–18/1	9·6	4·4	1·4	66
Transplanted	15/10	2/2–15/2	12·0	5·0	2·1	75

After harvesting, the onions were sun dried for eleven days and then stored in an aluminium-roofed shed with walls of sisal poles and an earth floor. Part of the crop was roped and hung from a beam 6 ft. above the floor and part was placed in a single layer in open crates. Decay began in the roped bulbs after two months and 50 per cent had to be discarded after four months, whereas bulbs began to decay in the crates after only 35 days and at four months 62 per cent had to be discarded.

Peas.—Six varieties of peas were tried in unreplicated plots at Molo. In order to test the value of Sevtox (D.N.B.P.) as a weed killer for use in peas under East African conditions, each of the plots was divided into four parts and a quarter was sprayed with this material. Plots of the varieties Rondo C.B., and Unica were sprayed with six pints per acre of Sevtox per acre in 100 gallons of water when the plants were about 8 in. high. This rate of application of the spray caused wilting of the peas and, consequently, all other plots were sprayed a few days later at the rate of 5 pints of Sevtox per acre dissolved in 100 gallons of water. The effect of the lower rate of application was a total kill of all broad-leaved weeds with no noticeable effect on the peas. Subsequently, the cover provided by the pea crop kept weeds in check. The peas commenced to flower about the end of October, the first varieties being Unica and Vares followed by Zelka and Servo, the latest of all being Rondo C.B. and Emigrant. The results are summarized in Table VIII. Owing to the wet weather, the quality of peas harvested was low and an estimate of the percentage of good peas from each variety is shown in the table.

TABLE VIII

Variety	Length of straw	Pulling date	YIELD LB. PER ACRE		Percentage good peas, 1954
			1953	1954	
	in.				
Vares ..	16	1/12	—	1445	90
Servo ..	13	9/12	1801	2400	86
Unica ..	13	9 and 13/12	2511	2046	85
Emigrant ..	28	13 and 20/12	846	2577	95
Zelka ..	22	13 and 20/12	1268	1454	93
Rondo C.B.	10	2 and 9/12	1313	1693	80

Beans.—A variety trial with nine varieties of beans, listed in Table IX, was carried out at Molo and Subukia, but the results from the latter site are still awaited. At Molo, the experiment was on a volcanic red loam of good depth and no fertilizer or manure was applied. Seed was sown by hand in drills 24 in. apart with 3 in. between the seeds in the row on 10th and 13th August and good germination was obtained 10 to 12 days after planting. The plants were slow in

growth owing to the dull weather. All varieties except Refugee were flowering eight weeks after planting, the first picking took place a month later and harvesting continued until mid-December. Landreth's Stringless Green-pod and Burpee's Stringless Green-pod appeared to be the same variety. All varieties were marketed in Nairobi and were well received on the fresh market, except Pencil Black Wax which has a very curled pod and a yellow colour.

A disorder known as "Bald Head" which, it is understood, is caused by damage to the seed at harvest time and during cleaning was noticed soon after the seedlings emerged, and about 5 per cent of plants of all varieties was affected. About mid-September, an unidentified disease resulted in the leaves of the young plants becoming covered with brown spot. With the onset of better weather, the plants grew away and threw out new leaves which were unaffected, but later the disease again became general and spread to the pods, resulting in a proportion of them being unfit for sale. The percentage killed by this disease of each variety at the last picking is shown in Table IX. The plants are believed to have been adversely affected by wet weather and wind, and there was probably a correlation between the effect of these factors and the incidence of brown spot disease.

Results of the trial are summarized in Table IX from which it will be seen that the variety Mont d'Or produced the highest yield per acre and had a low percentage of curled pods and a low disease incidence. However, its yellow colour makes it unattractive on both the fresh market and for canning and the variety Full Measure will probably prove to be more satisfactory.

TABLE IX

Variety	Plant		Pod Characteristic		Yield per acre	Approx. killed by fungus by last picking
	Average height	Flowering	Approx. curled colour per cent	Remarks		
	inches				*lb.*	*per cent*
Giant Stringless Green-pod.	14	Early ..	50% Green ..	Full	3,388	80
Full Crop	12	Early ..	20% Green ..	Round	3,580	5
Mont d'Or ..	13	Mid-season	10% Yellow ..	Oval	8,307	10
Full Measure ..	15	Mid-season	30% Green ..	Round fleshy	8,000	1
Burpee's Stringless Green-pod.	14	Early ..	50% Green ..	Flat	3,939	1
Landreth's Stringless Green-pod.	14	Early ..	50% Green ..	Flat	4,730	1
Tendergreen ..	10	Fairly Early	20% Green, slight black markings.	Round	6,583	20
Pencil Black Wax ..	10	Mid-season	90% Yellow ..	Flat	3,427	10
Refugee Idaho ..	10	Late ..	20% Green, black markings	Oval	3,500	20

Asparagus.—An observational trial with the variety Mary Washington was continued at Molo. This compares two spacing (4 ft. x 1½ ft. and 7 ft. x 1 ft.) and two cutting frequencies—once or twice a year. As there appear to be two dormant seasons in a year it is thought that it may be possible to have two cutting seasons a year, but the effect of this on yields and on the life of the crowns has not yet be determined. No conclusions can yet be drawn from the yields for 1953 and 1954, which are shown in Table X, but it does appear that the wider spacing is an advantage. The lower yields in 1954 are partly due to a number of crowns failing to shoot this season. The reason for this is not fully known but a severe attack of the fungus *Sclerotinia sclerotiorum* during the main growing season certainly weakened some of the crowns.

With the object of obtaining material for a future statistical yield trial a second lot of crowns of the variety Mary Washington was raised and planted out in August, 1954. Before planting, crowns were divided into three groups for size, grade 1 and 2 being planted and group 3 being discarded. Subsequent establishment of groups 1 and 2 was practically 100 per cent but growth of grade 1 is much superior to that of grade 2. An improved strain of Mary Washington known as 499 was received from the University of California and has been planted for trial. Trial plots of asparagus were established at Kakamega and Kitale.

TABLE X

Plot Spacing	Yield, lb per Acre				Total	
	April Cutting		September Cutting			
	1953	1954	1953	1954	1953	1954
1. 4 by 1½ ft.	623	859	2148	1212	2771	2071
2. 4 by 1½ ft.			1942	1337	1942	1337
3. 7 by 1 ft.	593	1008	2504	1318	3097	2326
4. 7 by 1 ft.		1879	1653		1879	1653

Gherkins.—A preliminary trial with three varieties of Gherkins was started at Rongai on deep fertile volcanic loam at an elevation of 6,100 ft., with the object of estimating whether the crop is likely to be economic and find a variety suitable for pickling. The varieties under test were Bonne Ville, Long English Prickly, and Small Paris Gherkin. Bonne Ville was a fortnight later in flowering than the other two varieties. The first picking was made on the 26th November and harvesting is still continuing, the Small Paris producing the highest yield to date. The plants were affected by an unknown leaf disease and the Gherkins have been pierced by an unknown parasite and attacked by the larvæ of fruit flies (*Trypetidæ*). The quality of the pickled product appears to be good with all varieties, but Long English Prickly is not considered very suitable owing to the long thin shape of the fruit. Small Paris proved to be of excellent quality and will probably be the best yielding variety.

Acknowledgments

In conclusion, I would like to thank the staff of the Horticultural section for the greatly increased volume of work carried out during the year. Great assistance has also been rendered by the staff of other sections, particularly in carrying out work in co-operative experiments.

T. H. JACKSON,
Agricultural Officer (*Horticulture*).

ANNUAL REPORT OF THE SENIOR CHEMIST (PYRETHRUM) FOR 1954

Extracts

A change in the main export policy occurred during the year, namely the major portion of the crop is exported in the form of concentrated extracts. The vast amount of this produced made it patent that much investigation was called for on many lines. It is not possible to go into details of the many investigations as much of the work opened new lines which would be of much value to the trade. Suffice it to say that a great deal of valuable information was gained due to the hard work and efficient guiding by Mr. Hopkins and his staff.

"Pyrethroids"

The writer pursued the lines discussed in last year's report, but, unfortunately, illness interfered with the prosecution of this work. It can be stated definitely that there are variations between individual plants in the relative proportions of "pyrethrins" and "pyrethroids".

However, a profitable line of research, which promises to be of great value, on more detailed aspects of the study has been pursued by Mr. H. C. Hodgson, whose report follows:—

> "Investigations have continued with a view to elucidating further the nature of the "pyrethroids" or false pyrethrins. For this purpose the technique of paper chromatography and counter-current distribution have been successfully applied.
>
> Chromatographic examination on paper of a number of Py. I and Py. II acid hydrolysates has shown that whereas the chrysanthemic acid from pyrethrins I is apparently uncontaminated, the chrysanthemum dicarboxylic acid fraction may contain at least two barium-soluble acidic impurities. This is particularly the case where the Py. I/Py. II ratio is unusually low. It must not be assumed, however, that a relatively high assay figure for pyrethrins II necessarily denotes impurity, for in some cases, the melting point of the crystalline total acid fraction has shown very good agreement with the accepted figure for the pure acid. On the other hand a low Py. I/Py. II ratio does indicate a possibility of appreciable pyrethroid contamination and should, accordingly, be suspect. It is clear from the above that the present assay methods leave much to be desired in regard to their specificity for chrysanthemum dicarboxylic acid.
>
> Since chrysanthemic acid is unusual in combining the properties of ease of solution in petroleum ether with ready aqueous solubility of its barium salt, and since the chemical assay method is based on its reducing power, there is very limited possibility of interference from other acidic material. In fact a comparison of the empirical saponification equivalents for Py. I hydrolysates with the theoretical figure for pure chrysanthemic acid has, in the cases examined, shown almost complete agreement. By contrast, the pyrethrin II determination is quite unspecific and could include any acid giving a soluble barium salt.
>
> The Craig counter-current distribution technique has proved of value in the study of pyrethrin extracts and has shown interesting possibilities in regard to the investigation of the non-pyrethrin constituents which influence the physical properties of the extracts as a whole. Basically, the method consists of repeated linear partition of the extract between two immiscible solvents

when the component substances are distributed among the various fractions according to their respective partition coefficients. Initial experiments have been restricted to nine-stage partitions between petroleum ether and alcohol since the method is laborious and protracted if performed manually on a large scale. Even on this relatively small scale a number of interesting observations have been made.

The earlier fractions have been found to consist largely of biologically inactive unsaturated esters giving negligible pyrethrin assay figures but appreciable barium insoluble acid hydrolysates. They polymerize extremely rapidly even in the absence of light and air, yielding polymers insoluble in petroleum ether and chloroform, and could conceivably play an important part in initiating polymerization of the pyrethrins. If this is, in fact, the case then it is clearly important in breeding to select those strains which give low proportions of these substances.

The pyrethrins themselves occur largely in the middle fractions and their peak concentrations show a distinct separation into two main groups. A further indication of the relative amounts of the individual pyrethrins in each fraction was obtained by the application of the reversed-phase paper chromatographic method. A graphical plot of the summated curves for Py. I and Py. II chemical assays against fraction number was almost superimposable on the corresponding spectrophotometric curve for total pyrethrins.

This would appear to indicate that the "pyrethroids" contain the same or similar moieties as the true pyrethrins. Unfortunately a suitable method for detecting chromatographically the presence of extraneous acids had not been developed at the time of this experiment.

It was hoped to be able to obtain a comparison of the relative toxicities of pyrethrins I and II but the methods available proved insufficiently sensitive for the degree of separation achieved.

Publications

V. A. Beckley and J. Hopkins, "Determination of Pyrethrin I". *Soap and Sanitary Chemicals,* January, 1954.

V. A. BECKLEY,
Senior Chemist (Pyrethrum).

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (PYRETHRUM), 1954

Meteorological

Detailed meteorological recordings for the various pyrethrum stations will be found in the Appendix of this report.

Rainfall during 1954 was up to average in most pyrethrum-growing areas and as a whole well distributed. Yields per acre, however, varied considerably with locality, very largely due to the number of sunshine hours prevailing at different periods. Sunshine was slightly less than in 1953, which it is thought influenced flowering. This is reflected in the total flower production, which amounted to 4,621,844 lb., only 74,574 lb. more than in the preceding dry year. Other reasons for this perhaps disappointing figure are a considerable diminution of the pyrethrum acreage in such important districts as Thomson's Falls and the North Kinangop and excessive weed growth at the beginning of the season coupled with labour shortage on many farms. On the other hand, flowering was still quite heavy by the end of December so that the effect of the favourable rains in 1954 might still be noticeable at the beginning of 1955. The average pyrethrin content of 1.58 per cent compares well with that recorded in previous years. The rains started at the beginning of April and most of the experimental planting on the various stations was completed during this and the following month.

Experimental Work

(*a*) Bud Disease

Cutting-back Trial

Reference is made to Part I 5 (*d*) 2 of this Section's Annual Report for 1953. It was reported that plants which had been cut back right down to ground level before the beginning of the rains were less severely affected by the fungus *Ramularia bellunensis* up to the fifth picking only, after which the disease rate evened out in the various treatments. This trial was repeated in 1954 in a stand of C.47. The uncut control plots were placed apart from the two other treatments (cut low and cut high) in order to avoid as much as possible contact with old plant material and dry stalks as potential carriers of the fungus spores. Contrary to the findings of the 1953 experiment the flower yield was influenced by the different treatments, there being a significant difference between the yield of normally (high) cut-back and that of the severely (low) cut-back plots and the controls ($P = 0.05$). It appeared that the mean flower weight was lowest and the disease rate highest in the plants which had not been cut back ($P = 0.01$).

Although a lower disease rate in the severely cut-back plots could be observed only up to the sixth picking, the difference in the rates was nevertheless significant between these and the high-cut plots ($P = 0.001$). The results are given below:—

Treatment	Flower Yield	Disease Rate	Mean Flower Weight
	lb./acre	*per cent*	*gms.*
Control	687	6·7	0·62
Cut Low	642	2·8	0·69
Cut High	941	3·9	0·67

The incidence of *Ramularia* disease was low. Results of a number of cutting-back trials have not always conformed to the same pattern but it is thought that cutting back in the normal manner down to foliage level should be recommended at least as a matter of plant hygiene. Yields, as in the present trial and in some previous cases, may decline if the plants are not cut back, this probably being a seasonal effect.

(*b*) Picking/Mowing Trial

Reference is made to Part I 5 (*e*) of this Section's Annual Report for 1953, in which results are given for a trial conducted over the two seasons of 1952/53 and 1953/54. In April, 1954, a new trial was started with Clone 486 as planting material and six instead of four replications in the former trial. One treatment again consisted in unselective picking at 3-weekly intervals down to petals horizontal and the other in mowing. The plants being in their first season, they could be mown twice only, on 11th August and 24th November. Results were as follows:—

Treatment	Average Pyrethrins Content	Yield Pyrethrins
	per cent	*lb./acre*
Picking	1·79	4·59
Mowing	0·65	3·44

The difference in yield is significant at $P=0.05$. Considering that the material produced by mowing is bulky, containing stalks as well as flowers and buds, expensive to transport and probably difficult to extract on a large scale this treatment offers hardly a practical proposition.

(*c*) Nursery Trials

A trial with splits from Clone 481 was laid down during the dry weather under irrigation to test the effect of various manures and Seradix on the development of the root system. It would be valuable in the propagation of clones if by some method vegetative growth could be accelerated. It was found that dusting of the roots with Seradix powder had no effect. Triple superphosphate (200 lb./acres applied in the planting hole) and farmyard manure (10 tons/acre) both encouraged weed growth but only farmyard manure enhanced the development of the root system. 200 lb./acre sulphate of ammonia yielded no results. Rootless splits were a failure.

When establishing seedbeds, it was observed that the initial growth of the seedlings was more vigorous if brushwood had been burned on the land and the ash raked in. This may be due to the release of potash, although in none of the manurial experiments did this element ever show an effect, or to some other, more complicated process taking place in the soil through burning, but it is most probably an effect of the release of phosphorus.

(*d*) Phosphate/Ridging Trials

Reference is made to Part I 5 (*a*) of the present report. The most interesting results have been recorded within the experiment planted on Marindas Farm in 1952. The yields, in lb. of dry flowers per acre, have been as follows:—

	1952–53	1953–54	1954–55	Total
A. Plant on flat, no phosphate	228	692	754	1674
B. Plant on flat, 300 lb./acre Triple Supers. in plant-hole	257	928	759	1944
C. Plant on ridge, 300 lb./acre Triple Supers. in plant-hole	296	846	778	1920
D. Plant on ridge, 300 lb./acre Triple Supers. at base of ridge	362	1056	865	2283
E. Plant on ridge 100 lb./acre Triple Supers. in planting hole, 200 lb. at base of ridge ..	319	1041	809	2169
F. Plant on ridge, no phosphate..	264	758	755	1777
G. Plant on flat, ridge later, no phosphate ..	229	581	774	1584
H. Plant on flat, ridge later, 300 lb./acre Triple Supers. in planting hole.. ..	194	825	718	1737

During the first season the untreated plots yielded an average of 240 lb. per acre while the average for the plots receiving superphosphate was 286 lb., an increase of 46 lb. In the second year the controls produced a yield of 677 lb. of dry flowers per acre while the application of superphosphate raised the yield to an average of 939 lb. per acre. It appeared that the fertilizer placed underneath the ridge (treatments D and E) was most effective. By the last season, the effect of superphosphate placed in the planting holes had worn off, but the difference of 80 lb./acre in yield between the untreated plots and those which had received superphosphate at the base of the ridge was still significant ($P = 0.01$). It may be concluded that under similar conditions to those prevailing on Marindas Farm, i.e. on phosphorus-hungry soils, the placement of the fertilizer below the ridge ensures the most economical use of it. Taken over all three seasons, the plots which had been given superphosphate yielded 333 lb. of dry flowers more than the controls (2,011 lb. *vs.* 1,678 lb.), a difference in yield not only statistically significant ($P = 0.01$), but also important from the economical point of view.

The experiment at Kipkabus has given results only over the first two seasons showing a slight increasing effect through superphosphate (33 lb./acre) and ridging (70 lb./acre). The trials on the Kinangop and at Londiani yielded no results.

(*e*) Phosphate Placement Trial

Reference is made to Part I 5 (*a*) of this Section's Annual Report for 1953. The trial was planted at Ol Joro Orok in 1952.

No treatment effects were observed during the season, the third and last year of the experiment. The average flower yield was 621 lb. per acre. The results have been disappointing as only during the first season the yield was increased by 16 lb./acre ($P = 0.01$) through planting on the ridge and by 12 lb./acre ($P = 0.05$) through subsoiling, the mean flower yield of that year being 65 lb. per acre.

(*f*) Large Rotation Trial

Reference is made to Part II 2 (*a*) of this Section's Annual Report for 1953. It was observed that, possibly as a result of the scanty rainfall during 1953 combined with a loss in soil structure, the plots bearing continuous pyrethrum showed

indications of a drop in yield as compared with pyrethrum succeeding a grass ley. Results for 1954 are not very clear cut, the climatic conditions having been more favourable, but again yields from the plots bearing pyrethrum for now eight seasons running seem to be slightly inferior to those obtained from pyrethrum following a grass ley or even wheat. Interesting results were recorded for the plots sown with cereals. Wheat immediately succeeding pyrethrum yielded 86 lb./acre more than wheat grown for the second time and 539 lb./acre more than wheat planted for the third year in succession. The trial will be continued.

Plant Breeding

The number of single plant selections was severely reduced although some new selections were made within populations of hybrids with known parentage, produced on the various stations, and from a field established several years back with the original material imported from Dalmatia. It was thought that a sufficiently large quantity of tested clones was available for further breeding work or, if desired, for the direct issue to growers and that it was undesirable to extend the number of single plant selections before facilities for insecticidal tests became available. For the same reason no new crosses (hybrids) were made during the season. A certain number of isolated plots at Molo, Ol Joro Orok and Subukia had, however, to be kept open because they had not yielded sufficient seed in 1953, and more were established to study pollination problems. For the sugar beet breeding system 11 plots were laid down in Molo and Subukia. Altogether 272 single plant selections were kept under observation and 243 tested and promising clones were bulked up on the various stations. It was hoped that biological assays could be carried out on a fair number of these clones during the season, but apart from seven samples of C.47 flowers, which were collected over a wide range of the pyrethrum-growing areas and sent to England for chemical and insecticidal tests, it was not yet possible to embark on a more extensive programme in this direction. As far as chemical work on some of the selected clones indicates, a high proportion of Pyrethrin II seems to be connected with a comparatively large amount of pyrethroids (non-toxic false pyrethrins). This factor has to be taken into consideration when selecting clones for breeding purposes. The first examinations for the yield and pyrethrin content were made with a number of Dalmatian seedlings. A series of trials was undertaken to study the botanical aspect of pollination and seed setting; although more work will have to be undertaken to confirm the findings it is highly probable that self-pollination occurs only in very rare cases and that cross-pollination carried out by insects between two different clones is essential for the production of viable seed.

The most important of the new hybrids (crosses) and their parent clones were tested in 15 yield trials which were placed on the various stations as well as on representative farms over a fairly wide expanse of the pyrethrum-growing areas. A good performance could again be recorded for C.43, C.51, C.77, C.79 and M.9 at different altitude levels.

No more seed was issued from the mixed cross plot at the Grassland Station or from 1970 Control at Molo. One acre each of seed production fields for C.43 and C.51 were maintained and it is intended to enlarge these in 1955. In addition, a quantity of seed was harvested from vigorous and tested plants on the various stations and issued as "Molo Bulk" and "Subukia Bulk". Altogether 933 lb. of seed were supplied to the Pyrethrum Board for issue to the growers.

Pests and Diseases

No alarming outbreak of bud disease caused by the fungus *Ramularia bellunensis* was reported although signs of the disease could be observed almost everywhere. Comparatively low mean temperatures and sunless periods were, one would have thought, conducive to the spread of the fungus spores. More serious attacks, probably as a result of those factors, were observed on the experiment stations at Molo, Subukia, Marindas and Ol Joro Orok. The outbreaks were not general but confined to different periods of the season, to certain areas of the plots and mainly to plants in their second season. Not all the diseased buds were attacked by *Ramularia bellunensis* however, a certain proportion of the outbreak was due to *Phoma* or *Ascochyta*. Little is known of the behaviour of this fungus at the moment and at least another season's observations are necessary before any more definite statements can be made.

The incidence of *Ramularia* disease at Ol Joro Orok increased towards the end of the picking season, an occurrence which has been observed before. The disease rates in the single plant selections at the various stations were as follows:—

	1953/54	*1954/55*
Molo	7.6	4.4
Ol Joro Orok	8.7	16.4
Grassland Station	0.6*	30.0
Subukia	6.0	11.4

*First season plants only.

Acknowledgments

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Finally, the untiring assistance and ready co-operation of the staff of this section, European and African, is gratefully acknowledged.

U. KROLL,
Agricultural Officer (Pyrethrum).

APPENDIX

Meteorological Data

(*a*) *Molo* (*altitude* 8,300 *ft.*)

1954	Mean Temp.	Rainfall	Sunshine
	°F.	*inches*	*hours*
January	56·8	0·42	270·6
February ..	58·4	0·09	268·4
March	59·6	0·20	276·6
April	58·3	6·19	183·9
May	57·6	9·57	210·8
June	55·6	3·45	182·0
July	54·4	6·32	150·1
August	54·4	7·60	170·7
September ..	55·0	5·12	192·9
October	55·8	2·46	242·8
November ..	55·6	2·37	191·0
December ..	56·9	1·66	223·6
Mean	56·5		
Total		45·45	2,563·4

(*b*) *Marindas* (*Grassland Station, altitude* 9,200 *ft.*)

1954	Mean Temp.	Rainfall	Sunshine
	°F.	*inches*	*hours*
January	54·8	0·00	254·7
February	57·4	0·00	242·6
March	57·4	0·00	242·6
April	56·2	5·30	186·7
May	55·4	11·93	165·5
June	52·9	6·63	160·8
July	51·7	7·11	110·8
August	51·5	9·20	125·6
September ..	52·3	6·49	174·7
October	53·7	3·60	222·3
November ..	53·4	1·43	205·7
December ..	54·7	2·66	206·7
Mean	54·4		
Total		56·73	2,302·9

(*c*) *Subukia* (*altitude* 7,000 *ft.*)

Meteorological Data

1954	Mean Temp.	Rainfall	Sunshine
	°*F.*	*inches*	*hours*
January	63·2	0·04	280·6
February ..	65·3	0·00	255·7
March	66·8	0·14	283·3
April	62·6	7·42	162·7
May	61·2	8·90	179·3
June	60·4	3·90	155·4
July	59·0	5·87	158·4
August	59·2	4·03	176·3
September ..	59·4	5·12	196·9
October	59·7	3·65	233·7
November ..	59·5	2·60	172·8
December ..	60·5	2·56	241·9
Mean	61·4		
Total		44·23	2,497·0

(*d*) *Ol Joro Orok* (*altitude* 7,800 *ft*)

Meteorological Data

1954	Mean Temp.	Rainfall	Sunshine
	°*F.*	*inches*	*hours*
January	55·7	0·08	—
February ..	56·7	0·33	—
March	56·8	0·07	—
April	57·3	3·64	174·1
May	56·2	6·39	182·5
June	53·8	4·83	161·6
July	54·6	7·98	151·6
August	53·8	4·30	135·4
September ..	54·2	5·95	200·3
October	54·8	1·82	235·5
November ..	55·7	0·69	174·3
December ..	56·4	1·09	225·8
Mean	55·5		
Total		37·17	

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Weather

	Rainfall	Average previous 13 years
		inches
January	0·06″ in 1 day	0·85
February	0·79″ in 3 days	0·85
March	0·06″ in 1 day	3·64
April	12·86″ in 17 days	8·98
May	9·49″ in 18 days	7·16
June	2·33″ in 9 days	1·00
July	0·89″ in 2 days	0·44
August	0·33″ in 3 days	0·72
September	0·29″ in 3 days	0·70
October	0·81″ in 6 days	1·86
November	5·30″ in 22 days	5·62
December	0·57″ in 4 days	3·54
Total	33·78″ in 89 days	32·36

The average rainfall for the 14 years of recording at this station, 1941–1954, is 32.47 in. The long rains were late in starting and began in the beginning of April. After a dry spell lasting 10 days in April they continued to the beginning of June, the total rainfall being above average. The short rains fell evenly over most of November, with regular small showers, the biggest only precipitating 0.55 in., and deep penetration of moisture is not what could be expected from the total rain fallen.

Nursery Trials

Nursery Manurial and Mulching Trial

The third cycle, planted 24th November, 1953, is scheduled to be lifted in April, 1955, so no new results were obtained during 1954.

Nursery Nitrogen and Lime Trial

Object.—To ascertain the effect on soil and sisal plants of various nitrogenous fertilizers.

Date of Commencement.—First cycle planted 16th April, 1953, and lifted 8th November, 1954. Second cycle planted 15th November, 1954.

There were no significant differences in the weight of plants lifted at the end of the first cycle. The trial is being repeated with each plot in the same position as the first cycle.

Planting Material Trials

Planting Method Trial

Object.—To compare yields when using graded old suckers from overgrown fields, graded young suckers from two-year-old fields and graded nursery plants produced from bulbils.

Date of Commencement.—24th April, 1949.

Spacing.—12 ft. × 2 ft. 6 in. (1,452 plants per acre).

Planting Materials

Old suckers, 19 in. high, weighing 6 lb.

Young suckers, 15 in. high, weighing 1½ lb.
Nursery plants, 18 in. high, weighing 4–5 lb.

Depth of Planting

Deep.—7 in. deep for young suckers; 9 in. deep for old suckers and nursery plants.

Shallow.—Approximately 3 in. deep for all three planting materials.

Design.—6 × 6 Latin square.

At the recording for November, 1954, there was very little difference in the numbers of leaves produced in the three different planting materials, but the shallow-planted had produced more leaves than deep-planted. The average increase in leaf number per plant during the year was about 27 leaves for all three planting materials. The variations in leaf length were very small, but the length of leaves in the young suckers are still slightly shorter than the nursery plants and old suckers.

All treatments were given a third cut in January, 1954, and poling plants were cut out in July, when poling in old sucker plants amounted to 14 per cent, while the poling percentage in nursery plants was about 7 per cent, and in young suckers just under 4 per cent. The trend of yield figures for tons of fibre per acre after the third cut is similar to last year's, with the total now in the region of 2 tons for old suckers and nursery plants and 1.70 tons for young suckers, but as poling is now beginning to influence the yields, comparative figures are held in abeyance till poling becomes more general. For each ton of fibre produced, nursery plants and suckers needed about 115,000 leaves in the first cut, 66,000 in the second, and about 48,000 in the third, while the young suckers needed 140,000, 82,000 and 53,000 respectively. This appears to be caused by the slightly shorter leaves cut in the young suckers.

PLANTING MATERIAL TRIAL

Object.—To investigate the possibility of obtaining greater efficiency by using larger nursery plants and to investigate the effect of an earlier first cut than is normal practice in Kenya.

Date of Commencement.—3rd November, 1950.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Planting Material

Nursery plants 9 in. high, weight about 1 lb.
Nursery plants 15 in. high, weight about 3–3¾ lb.
Nursery plants 21 in. high, weight about 6½–7 lb.

Age at First Cut

Early.—80–90 leaves produced since planting.
Normal.—100–110 leaves produced since planting.
Late.—120–130 leaves produced since planting.

Intensity of Cut

Heavy.—Leaving 25 leaves after first cut and 20 leaves after subsequent cuts.

Medium.—Leaving 35 leaves after first cut and 30 leaves after each subsequent cuts.

Light.—Leaving 45 leaves after 1st cut and 40 leaves after each subsequent cut.

Design.—3^3 factorial confounded. Two replications.

The development of the plants can best be expressed as follows:—

Planting Material	No. of leaves at planting	No. of leaves produced from planting to Nov., 1954	Total No. of leaves per plant	Length of last unfurled leaf Nov., 1954
				inches
9 inches	13·8	144·6	158·4	43·98
15 inches	24·2	144·2	168·4	43·27
21 inches	32·7	152·5	185·2	47·56
1st Cut at—				
80– 90 leaves	23·6	149·1	172·7	43·74
100–110 leaves	23·3	145·8	169·1	44·29
120–130 leaves	23·8	148·4	172·2	46·77
Cutting Intensity—				
Leaving:				
25 leaves	23·4	148·3	171·7	44·92
35 leaves	23·7	148·9	172·6	46·06
45 leaves	23·7	146·1	169·8	43·82

The various treatments have had little effect on the rate of leaf production, although the biggest planting material has produced slightly more leaves since planting than the smaller plants. The biggest planting material has now produced the longest leaf. This is due to the fact that this material had initially more leaves at the time of transplanting and consequently reached a given leaf sequence number before the smaller plants. It has been found that the leaf length for any given leaf sequence number, including the leaves on the plants at the time of planting, is similar in all the planting materials.

All the plots in the trial have now had two cuts and the effect of the cutting treatments are beginning to become apparent in the length of leaves produced subsequent to these cuts, although the differences are still small. The tendency appears to be for the early first cuts to retard the natural increase in the length of the leaves produced subsequent to the cuts. This may or may not be a transitory factor and may disappear after the trial moves into a regular cutting cycle of one cut per year.

The state of leaves cut can best be expressed as follows:—

Planting Material	No. of Leaves Cut per Plant			Tons of Fibre per Acre			No. of Leaves per Ton Fibre in Thousands		
	1st cut	2nd cut	Total	1st cut	2nd cut	Total	1st cut	2nd cut	Av.
9 inches	24·7	32·2	56·9	0·39	0·77	1·16	125·4	82·8	97·1
15 inches	25·9	31·6	57·5	0·40	0·80	1·20	128·2	78·2	94·9
21 inches	34·0	33·9	67·9	0·65	1·02	1·67	103·6	65·8	80·5
1st Cut at—									
80– 90 leaves	12·9	45·9	58·8	0·16	1·04	1·20	159·6	87·4	97·0
100–110 leaves	33·9	28·7	62·6	0·52	0·82	1·34	129·0	69·3	92·5
120–130 leaves	37·9	23·0	60·9	0·76	0·73	1·49	98·7	62·4	80·9
Cutting Intensity—									
Leaving:									
25 leaves	36·5	33·1	69·6	0·65	0·97	1·62	111·2	67·6	85·1
35 leaves	28·1	32·7	60·8	0·47	0·87	1·34	118·4	74·4	89·8
45 leaves	20·1	31·8	51·9	0·32	0·76	1·08	124·4	82·8	95·2

With the different stages at first cut the proportion of shorter leaves to long leaves varied considerably in the earlier cuts. To ascertain to what degree this took place the leaves were sorted before decortication into two grades, one of short leaves under 30 in. in length and the other of leaves over 30 in. in length.

The results are as follows, in tons of fibre per acre:—

Planting Material	First Cut		Second Cut		Wt. of Fibre Tons		Total Fibre tons	Fibre Ratio Long Short
	Short Fibre	Long Fibre	Short Fibre	Long Fibre	Short	Long		
9 inches	0·13	0·26	0·04	0·73	0·17	0·99	1·16	5·82
15 inches	0·16	0·24	0·02	0·78	0·18	1·02	1·20	5·71
21 inches	0·16	0·49	0·003	1·02	0·16	1·51	1·67	9·44
First Cut at—								
80– 90 leaves	0·11	0·05	0·04	1·00	0·15	1·05	1·20	6·93
100–110 leaves	0·19	0·33	0·004	0·82	0·194	1·15	1·34	6·05
120–130 leaves	0·16	0·60	0·005	0·72	0·165	1·32	1·49	8·19
Cutting Intensity—								
Leaving:								
25 leaves	0·18	0·48	0·002	0·96	0·182	1·44	1·62	7·94
35 leaves	0·15	0·32	0·01	0·86	0·16	1·18	1·34	7·37
45 leaves	0·13	0·19	0·04	0·72	0·17	0·91	1·08	5·35

The figures show that the largest planting material gives a higher proportion of long fibre in the first cut and only a small proportion of short fibre in the second cut. More leaves have been cut and more tonnage produced from leaves of greater length in the plots planted with the biggest planting material. This is clearly shown by the smaller number of leaves needed to produce one ton of line fibre.

It will be noted from the figures that the total number of leaves cut per plant after two cuts varies little, but the state of the leaves is seen in the tonnage of fibre and in the number of leaves needed to produce a ton of fibre. It may be uneconomic to decorticate leaves in an early first cut, when as many as 159,000 leaves are required to produce a ton of fibre, and it may even be preferable to leave them in the field if this cut it necessary to prolong the life of the plant and thus produce more leaves. The effect of these cuts on the future life and on poling will, however, have to be studied before any conclusion can be reached. The effect of cutting intensity cannot be assessed until the cycle has advanced a good deal further as many more leaves have been cut off the plants which have been more severely cut.

Bulbils, Nursery Plants and Suckers Trial

Object.—To compare bulbils planted *in situ* in the field with nursery plants and suckers, and further to compare flat and ridged planting on red soils.

Date of Commencement.—7th November, 1950.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments

Bulbils.—Average weight 3 oz., planted *in situ* in fields.
Nursery plants.—15 in. high, weight 3–3¼ lb.
Suckers from old areas.—25 in. high, weighing 10–12 lb.
Ridged *vs.* flat.

Design.—6 × 6 Latin square.

Due to the great unevenness in size at planting of the three different planting materials, an arbitrary decision was made to take the first cut when the average length of the last unfurled leaves became 120 to 135 centimetres (47–53 in.). The gap may appear big but is justified by the variation between and within plots. While the bulbils are still uncut, the suckers reached this stage in January, 1954, and the nursery plants in September, 1954. The differences between suckers and

nursery plants in number of leaves cut, weight of leaves, or tons of fibre per acre are small and the trial must advance further before results can be given. The slightly better performance so far of ridged over flat planting hardly justifies the extra expense of ridging.

Cured Planting Material Trial

Object.—To investigate the effect on nursery plants of a curing process for varying lengths of time before planting out in the field.

Date of Planting.—Before long rains, 18th April, 1953; before short rains, 15th November, 1953.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments.—Curing in the sun and under cover for three, two and one month before planting in the long and short rains versus the planting of fresh material.

Design.—Randomized blocks, two replications.

It is still too early to comment freely on the results of this trial, but they would indicate that the subject warrants further investigation as there is a tendency for the plants with the longest period of drying to produce more leaves, although this relation is not found in length of leaves produced. There appears to be a slight tendency for the shaded plants to be a little better than the unshaded group cured in the hottest season. The other group is still too young to show any differences. As any effect which is apparent at present may easily be masked in a few years or even months, the only significant factor arising from this trial to date is the fact that plants left unplanted for up to three months, whether shaded or not, have struck roots and appear to be growing normally.

Plant Management Trials

The object of the following five trials is to ascertain variations in growth rates in various districts of Kenya, using different spacing and cutting treatments. Treatments for spacings are as follows, with the figures in the body of the table giving the distance between plants in the row:—

Plant Populations per Acre	1200	1600	2000
Row Spacing	Distance between Plants in Row		
14′	31″	23″	18″
11′	39″	29″	23″
18′ × 3″	41″	31″	24″

Development at First Cut

100 leaves grown since planting.
125 leaves grown since planting.
150 leaves grown since planting.

Severity of Cutting

Light.—Leaving 30 leaves after each cut.
Medium.—Leaving 20 leaves after each cut.
Heavy.—Leaving 10 leaves after each cut.

Design.—3^4 factorial, arranged as a 9 × 9 Quasi Latin square.

The differences needed between two figures to be significant are expressed on two probability levels of 95 per cent and 99 per cent at the bottom of each column as P = 0.05 and P = 0.01, while each column represents one of the subjects under investigation.

Ruiru Trial (Black Cotton Soil) Ridged

Locality.—Juja Farm, Ruiru.

Date of Commencement.—16th March, 1948.

The summary of results of this trial is best expressed as follows:—

	Total leaf count	Length of last leaf grown *inches*	No. of leaves cut per plant	Weight in lb. of leaves cut per plant	Weight of fibre tons per acre	No. of leaves per ton of fibre	Fibre *per cent*
SPACING—							
14 ft.	156·6	41·97	73·2	79·1	1·74	72,800	3·22
11 ft.	162·6	41·46	75·5	84·1	1·92	71,300	3·27
18 by 3 ft.	165·4	42·68	83·4	91·1	2·01	68,900	3·22
POPULATION—							
1,200	182·3	43·98	103·8	122·4	2·24	57,900	3·36
1,600	156·2	40·98	67·0	71·0	1·66	73,000	3·22
2,000	146·1	41·10	61·3	60·9	1·78	82,000	3·14
FIRST CUT AT—							
100 leaves	166·1	39·61	91·7	94·8	2·24	73,700	3·37
125 leaves	159·9	42·24	84·6	89·2	1·88	74,100	3·13
150 leaves	158·5	44·21	55·8	70·3	1·55	65,100	3·21
CUTTING—							
Light	161·9	42·91	69·6	77·2	1·77	72,700	3·28
Medium	164·0	42·52	78·7	92·3	2·01	69,800	3·23
Heavy	158·8	40·63	83·8	84·8	1·90	70,300	3·21
P=0·05	7·9	2·32	13·6	20·5	0·49	8,000	0·06
P=0·01	10·7	3·15	18·3	27·6	0·66	10,800	0·08

The differences needed between two figures to be significant is rather big in this trial due to the great variations between the plots in the trial.

TRANS NZOIA TRIAL

Locality.—Ziwa Limited, Hoey's Bridge.

Date of Commencement.—10th April, 1948.

A summary of the results obtained in September, 1954, is given below:—

	Total leaf count	Length of last leaf grown *inches*	No. of leaves cut per plant	Weight in lb. of leaves cut per plant	Weight of fibre tons per acre	No. of leaves per ton of fibre	Fibre *per cent*
SPACING—							
14 ft.	208·2	43·78	124·35	161·77	3·16	63,500	2·80
11 ft.	219·4	44·02	133·16	181·30	3·66	59,000	2·87
18 by 3 ft.	211·0	43·31	125·01	164·29	3·27	61,400	2·82
POPULATION—							
1,200	229·5	44·57	144·09	205·34	3·24	54,500	2·92
1,600	212·0	43·90	127·11	167·68	3·45	60,500	2·84
2,000	197·2	42·76	111·28	134·32	3·40	68,800	2·74
FIRST CUT AT—							
100 leaves	211·5	42·16	130·63	157·94	3·37	62,700	3·03
125 leaves	210·9	42·79	126·07	164·09	3·18	64,100	2·76
150 leaves	216·2	46·22	125·78	185·31	3·54	57,200	2·71
CUTTING—							
Light	214·8	45·67	114·71	152·45	2·92	63,200	2·74
Medium	213·9	44·21	130·08	177·32	3·53	59,300	2·86
Heavy	210·0	41·26	137·73	177·60	3·63	61,400	2·90
P=0·05	2·91	0·81	1·78	9·65	0·23	2,530	0·05
P=0·01	3·92	1·09	2·40	13·0	0·31	3,410	0·07

This is one of the most even trials in progress, but the rate of leaf production and leaf length is slightly lower than in the trials at a lower altitude.

KAMPI-YA-MOTO TRIAL

Locality.—Alphega Estate, Kampi-ya-Moto.

Date of Commencement.—23rd October, 1948.

A summary of results obtained in September, 1954, is given below:—

	Total leaf count	Length of last leaf grown *inches*	No. of leaves cut per plant	Weight in lb. of leaves cut per plant	Weight of fibre tons per acre	No. of leaves per ton of fibre	Fibre *per cent*
SPACING—							
14 ft.	161·4	42·48	89·9	107·7	2·00	81,800	2·63
11 ft.	170·4	42·79	98·6	122·7	2·33	72,900	2·71
18 by 3 ft.	152·3	37·87	79·7	81·1	1·49	92,600	2·55
POPULATION—							
1,200	175·2	42·52	104·2	132·0	1·97	72,600	2·70
1,600	162·4	41·38	90·5	104·7	2·03	78,800	2·64
2,000	146·4	39·29	73·5	74·7	1·81	96,000	2·55
FIRST CUT AT—							
100 leaves	160·8	38·58	97·0	104·2	2·02	84,900	2·72
125 leaves	163·5	42·28	94·5	110·8	2·10	76,700	2·69
150 leaves	159·8	42·32	76·7	96·4	1·70	85,700	2·48
CUTTING—							
Light	161·4	41·65	79·9	89·5	1·63	87,200	2·59
Medium	160·1	40·83	88·0	101·9	1·91	84,900	2·62
Heavy	162·6	40·71	100·2	120·1	2·28	75,200	2·67
P=0·05	5·17	2·06	6·9	10·4	0·30	12,660	0·09
P=0·01	6·96	2·77	9·3	14·0	0·41	17,050	0·12

This trial is growing on a piece of rather uneven soil and of relatively low fertility compared with the surrounding country.

THIKA TRIAL (RED SOIL)

Locality.—Anglo-French Estate, Thika.

Date of Commencement.—17th November, 1948.

A summary of the recording for leaf count and leaf length as recorded in September, 1954, and for the last cutting in May, 1954, is given below:—

	Total leaf count	Length of last leaf grown *inches*	No. of leaves cut per plant	Weight in lb. of leaves cut per plant	Weight of fibre tons per acre	No. of leaves per ton of fibre	Fibre *per cent*
SPACING—							
14 ft.	182·5	45·75	100·08	136·17	2·69	62,300	2·83
11 ft.	199·8	46·06	113·32	163·41	3·34	55,100	2·90
18 by 3 ft.	183·7	44·80	96·22	124·12	2·47	63,900	2·81
POPULATION—							
1,200	207·6	45·39	118·07	174·88	2·75	53,900	2·89
1,600	186·6	45·43	101·42	134·69	2·77	60,700	2·84
2,000	171·7	45·79	90·14	113·94	2·98	66,600	2·81
FIRST CUT AT—							
100 leaves	191·5	42·36	115·48	136·86	2·94	65,500	3·01
125 leaves	187·9	44·05	108·98	147·36	2·86	63,300	2·74
150 leaves	186·7	50·24	85·16	139·30	2·70	52,400	2·78
CUTTING—							
Light	189·8	46·81	93·18	128·03	2·45	62,700	2·77
Medium	185·9	45·20	99·55	133·05	2·65	61,400	2·84
Heavy	190·3	44·65	116·89	162·62	3·40	57,000	2·92
P=0·05	3·54	1·10	3·91	10·61	0·28	4,420	0·05
P=0·01	4·77	1·48	5·27	14·29	0·38	5,960	0·06

Although this trial is planted on land which has been under sisal for a considerable number of years, it has grown very well.

KIBWEZI TRIAL

Locality.—Dwa Plantations Limited, Kibwezi.

Date of Commencement.—21st October, 1949.

A summary of the results obtained at the end of 1954 is given below:—

	Total leaf count	Length of last leaf grown *inches*	No. of leaves cut per plant	Weight in lb. of leaves cut per plant	Weight of fibre tons per acre	No. of leaves per ton of fibre	Fibre *per cent*
SPACING—							
14 ft.	157·3	50·2	88·07	125·03	2·90	49,000	3·35
11 ft.	169·5	49·7	98·67	144·47	3·49	45,200	3·43
18 by 3 ft.	159·6	49·9	85·62	118·68	2·76	49,800	3·31
POPULATION—							
1,200	178·6	50·9	107·73	162·54	3·01	43,800	3·41
1,600	161·4	49·4	88·31	125·55	3·05	47,700	3·35
2,000	146·5	49·4	76·33	100·09	3·09	52,400	3·33
FIRST CUT AT—							
100 leaves	161·6	46·6	102·07	126·75	3·07	53,500	3·46
125 leaves	162·9	50·0	96·19	136·84	3·19	48,700	3·33
150 leaves	161·9	53·1	74·11	124·58	2·88	41,800	3·30
CUTTING—							
Light	164·8	51·3	84·65	119·95	2·83	48,300	3·34
Medium	160·6	49·4	88·12	124·24	2·88	48,900	3·34
Heavy	161·0	49·1	99·59	143·98	3·44	46,800	3·40
P=0·05	3·9	1·2	3·67	9·33	0·23	2,270	0·06
P=0·01	5·2	1·6	4·95	12·56	0·32	3,060	0·09

This trial has to date grown faster than any other trial under the control of this station. There are definite indications that a first cut can be taken at a stage earlier in this area than in the areas of higher altitude. The loss of leaves over 2 ft. amounted to an average of 27 leaves per plant when the first cut was delayed to the stage of leaf sequence number 150, but this loss of leaves has not reduced the yield as much as might have been expected.

A disturbing feature of this trial is the incidence of bole rot, which seems to increase with the severity of cutting.

EFFECTS OF ROW SPACING

The plants have generally grown leaves faster where the row spacing is only 11 ft. This effect must be attributed to the fact that in the three populations the distance between plants within the row is always greater when the rows are closer together and in consequence plant competition is less. Although the spaces between the plants in the 18 ft. by 3 ft. spacings are slightly greater than in the 11 ft. spacing, the double row is obviously having the effect of increasing competition between the plants. The 18 ft. between the double rows is unnecessarily wide and in consequence reduces the distance between the plants in the rows. The row spacings appear to have had very little effect on the length of leaves produced.

EFFECTS OF POPULATION

The rate of leaf production has in all cases been related to population, the smallest population per acre and the consequent greater living space per plant, producing to date more leaves per plant. The number of leaves required to produce a ton of fibre has so far also increased as the population increases. It is, however, premature to jump to conclusions at this stage as the low populations will probably pole out before the high populations and the trend may quite easily be reversed as the cycle progresses.

Effects of Earliness of First Cut

In all cases the earliest first cut at leaf sequence No. 100 retarded the natural increase in leaf length. The effect can be clearly seen in tables giving the number of leaves required to produce a ton of fibre. On the other hand the number of leaves grown appear to be affected very little by the earliness of the cut.

It was found that in none of the trials were leaves lost when cutting commenced at the 100-leaf stage. At the 125-leaf stage an average of one leaf per plant was lost at Kampi-ya-Moto and on Thika red soil, while the number of leaves lost was 6–7 at Kibwezi. When cutting was delayed to the 150-leaf stage only an average of about half a leaf per plant was lost at Hoey's Bridge, five at Kampi-ya-Moto, about 20 leaves were lost per plant in Ruiru black cotton and on Thika red soils, while at Kibwezi 27 leaves were lost per plant. The loss of the lower leaves has been intentional and the differences in the losses have varied considerably from trial to trial. It must be remembered that these leaves are short and have a low fibre content. Early cutting may interfere with a plant's natural development and postpone poling, so it will be interesting to see the effect on the final yields.

Effect of Intensity of Cut

The intensity of the cutting has had little effect on the number of leaves grown, but the shortening of the leaves grown subsequent to the cuts may have the serious effect of reducing yields. It will be noted in the tables that the severest cuts have so far produced the highest yields, but it is important to remember that more of the mature leaves have been cut off per plant in the more severe treatments.

Double- *vs.* Single-row Trial

Object.—To compare various plant populations and row spacings, and to establish whether a certain plant population will perform equally well whether planted in single row or double rows, when the distance between rows is the same.

Date of Commencement.—15th April, 1952.

Treatments Populations.—1,600 plants per acre; 2,000 plants per acre; 2,400 plants per acre.

Distance Between Rows.—11 ft.; 13 ft.

Row Spacing.—Double rows, 3 ft. between rows; single rows.

Design.—3 × 2 × 2, partially confounded.

The last recording, in October, 1954, gave the following results:—

	Leaf Count					Leaf Length (ins.)				
	Double Row		Single Row		Mean	Double Row		Single Row		Mean
Row Spacing	11 ft.	13 ft.	11 ft.	13 ft.		11 ft.	13 ft.	11 ft.	13 ft.	
Plant Population—										
1,600	100·8	98·1	96·9	92·3	97·02	40·43	39·65	39·49	39·57	39·80
2,000	94·0	92·3	89·8	88·4	91·15	40·04	37·65	38·46	39·92	39·02
2,400	93·3	88·9	85·5	78·6	86·59	41·46	37·05	39·72	37·91	39·06
Mean	94·56		88·57			39·37		39·17		
Mean 11 ft.	93·39					39·96				
Mean 13 ft.	89·73					38·62				

The variations in leaf length have not yet reached significance, but the differences are significant for all three factors in the leaf count figures. It is worth noting that the double rows have produced more leaves than the single row, whether the spacing between the rows is 11 ft. or 13 ft. The 11 ft. spacing has produced more leaves than the 13 ft. row spacing, which could be expected as the distance between the plants will be greater in the first case, whatever the population is.

The relation between plants per acre and number of leaves per plant is also quite clear but it must be borne in mind that the total number of leaves produced per acre is in an inverted ratio to the number of leaves per plant, as follows:—

1,600 plants at 97.02 leaves = 155,232 leaves per acre.

2,000 plants at 91.15 leaves = 182,300 leaves per acre.

2,400 plants at 86.59 leaves = 207,816 leaves per acre.

Cultivation Trials

Cultivation Trial

Object.—To investigate the effect on the soil and sisal plants of continuous clean weeding by mechanical means as against restricted weeding with and without a controlled grass cover in the area between sisal lines.

Date of Commencement.—1st November, 1950.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments

(1) Grass strip slashed frequently to keep grass low.

(2) Grass strip cut periodically and the cut grass used as mulch round sisal plants.

(3) Clean weeded by frequent discing for the first three years, then as (1).

(4) Clean weeded by frequent discing for the first three years, then discing twice a year.

(5) Discing twice a year for the whole cycle.

(6) Clean weeding by frequent discing for the whole cycle.

This trial incorporates the above treatments with sisal planted on the flat and on ridges. The grass cover is obtained by sowing Rhodes grass (*Chloris gayana*) in 6 ft.-wide strips between the double rows.

Design.—Rectangular Lattice Square with four replications.

This trial was planted on virgin red soil of high fertility, and the plants grew faster and bigger than had previously been seen at this station. The trial was cut for the first time in June, 1953, at two years and eight months, when the average number of leaves produced per plant since planting was 110. The first cut yielded 0.84 tons of fibre per acre, the second cut, 12 months later, yielded 1.15 tons, making an average of about two tons of fibre per acre after three years and eight months, with an average of 81 leaves cut per plant. This is an outstanding performance which can be attributed to the high soil fertility. So far the various treatments have not affected leaf production and yields.

Fertilizer Trials

Fertilizer Trial

Object.—To investigate the effect on the growth rate of sisal plants by applying artificial fertilizers and/or sisal waste.

Date of Commencement.—16th March, 1950.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments

Ca = Agricultural lime (96 per cent Ca–CO3), broadcast over the whole treated area at the rate of 2.0 tons per acre, a month before planting.

W = Sisal waste as fresh sisal waste taken straight from a Corona decorticator, decorticating dry. The waste was applied at the rate of 107 tons wet waste per acre and dug in one month before planting in strips covering an area 4 ft. each side of the double rows.

N = Sulphate of ammonia applied at the rate of 388 lb. per acre in each of the first four years of the cycle.

P = Double superphosphate, applied in shallow trenches under the plants a week before planting at the rate of 260 lb. per acre. As the effect was quick but only lasted for about 18 months, an extra application at the rate of 150 lb. double superphosphates was given after three years.

K = Muriate of potash, applied at the rate of 395 lb. per acre for the first year and 300 lb. per acre during each of the next three years.

Design.—2^5 factorial.

The effects of the five treatments on number of leaves grown and on leaf length, based on the recording in October, 1954, are given below:—

	Average leaf count of plants without	Average leaf count of plants with	Mean effects
Ca	162·99	167·40	4·41 N/S
W	156·40	173·99	17·59 (P=0·001)
N	160·42	169·97	9·55 (P=0·001)
P	162·59	167·79	5·20 (P=0·05)
K	166·32	164·07	−2·25 N/S

	Average length of last unfurled leaf of plants without *inches*	Average length of last unfurled leaf of plants with *inches*	Mean effects *inches*
Ca	39·65	41·65	2·00 (P=0·01)
W	38·98	42·32	3·34 (P=0·001)
N	40·00	41·30	1·30 N/S
P	39·88	41·42	1·54 (P=0·05)
K	40·71	40·59	−0·12 N/S

When comparing the effect figures from the quarterly recording for leaf count and leaf length, interesting observations are being accumulated. The effect of Ca is a small, insignificant increase in leaf count quarter by quarter, the accumulative effect of which is almost significant. In leaf length the picture is, however, different as the effect of Ca was a small but significant difference the first two years, after which a considerably longer leaf was produced, an effect which reached its peak after four years, and is now gradually falling off.

The effect of fresh sisal waste has been a rapid development of new leaves from the start, reaching a peak within a year of planting and then gradually wearing off in the third year. The effect on the leaf length reached its peak at two and a half years, and although the plants continue to produce a leaf considerably longer than those plants without sisal waste the effect is now gradually wearing off.

The effect of N on leaf count has been small, spasmodic bursts of increased leaf production after each annual application of N, with the effect wearing off within a few months, while the last application after three years appears to have had a more lasting effect. The effect on leaf length has been smaller and only amounts to an increase lasting a few months, after which the effect disappeared.

The effect of P on leaf count was to give the plants a boost, which manifested itself within the first six months and wore off within 18 months. An extra application after three years has so far had no effect on leaf count. The effect on leaf length reached a peak about 18 months after application, and has since gradually diminished. Although the second application at three years had an effect of boosting the length of the leaves produced subsequently, it was of a smaller order than the initial application.

The effect of K has been insignificant but negative, both as regards to leaf count and leaf length.

The effect of the fertilizers on fibre yield at second cut can best be expressed as follows:—

	Ca	W	N	P	K
Average No. of leaves cut per plant.	+66·6	72·3	68·1	68·0	63·0
	−62·2	56·4	60·6	60·7	65·8
Effect	4·4*	15·9***	7·5***	7·3**	−2·8
Average weight lb. of leaves cut per plant.	+69·9	78·0	71·1	71·0	65·1
	−61·7	53·7	60·5	60·6	66·5
Effect	8·2*	24·3***	10·6**	10·4*	−1·4
Tons of fibre per acre ..	+1·40	1·57	1·37	1·38	1·31
	−1·26	1·09	1·16	1·16	1·35
Effect	0·14	0·48***	0·21**	0·22**	−0·04
No. of leaves per ton of fibre.	+96,490	92,910	96,870	95,950	98,890
	−101,560	105,150	101,190	102,110	99,160
Effect	−5,070*	−12,240***	−4,320*	−6,160**	−0,270

*P=0·05 **P=0·01 ***P=0·001

The increase of 15.9 leaves per plant in the waste plots with a population of 1,980 plants per acre means that 31,482 leaves more were cut per acre, and these extra leaves produced the 0.48 tons of line fibre obtained after two cuts only. The character of the leaves is clearly indicated by the 12,240 leaves less needed per ton of line fibre produced.

Sisal Waste and Minerals Trial

Object.—To compare the effect of different methods of applying fresh sisal waste, sisal waste reinforced with artificial fertilizers and artificial fertilizers alone.

Date of Commencement.—17th March, 1950.

Treatments

	Fresh Sisal Waste	Sulphate of Ammonia	Double Super Phosphate	Muriate of Potash	Agric. lime ($CaCO_3$ 96%)
	tons	*lb.*	*lb.*	*lb.*	*tons*
A. Control	Nil	Nil	Nil	Nil	Nil
B. Waste half dug in and half as mulch	107	Nil	Nil	Nil	Nil
C. Waste all dug in	107	Nil	Nil	Nil	Nil
D. Waste all as mulch	107	Nil	Nil	Nil	Nil
E. Waste half dug in and half as mulch with minerals added	107	390	65	325	0·42
F. Waste all dug in with minerals added	107	390	65	325	0·42
G. Waste all as mulch with minerals added	107	390	65	325	0·42
H. Minerals only	Nil	1,560	260	1,300	2·0

The waste, lime and superphosphate were applied before planting, as in the fertilizer trial. Sulphate of ammonia, applied with waste at the rate of 129 lb. per acre for the first year, and 87 lb. per acre during each of the next three years. Applied without waste at the rate of 522 lb. for the first year and 346 lb. per acre during each of the next three years.

Muriate of potash applied with waste at the rate of 130 lb. per acre the first year and 65 lb. during each of the next three years. Applied without waste at the rate of 520 lb. per acre for the first year and 260 lb. during each of the next three years.

Design.—Four randomized blocks of eight plots.

The following figures are obtained from the last recording in October, 1954, for leaf count and leaf length, while the other figures refer to the total yield obtained in February, 1954, when the second cut was taken.

	No Artificial Fertilisers				Artificials Added				P= 0·05	P= 0·01
	A	B	C	D	E	F	G	H		
Leaf Count	156·2	167·3	166·9	169·8	177·8	175·2	172·8	170·4	13·04	17·75
Leaf Length	41·42	39·80	39·45	40·63	44·72	42·20	42·91	40·63	4·15	5·65
Average No. of leaves cut per plant	58·0	66·02	64·14	66·74	76·20	76·30	74·01	70·06	9·89	13·46
Average wt. of leaves cut per plant	56·69	64·47	62·41	67·01	85·54	82·71	78·83	74·56	16·64	22·65
Tons of fibre per acre	1·15	1·37	1·34	1·42	1·72	1·70	1·64	1·56	0·31	0·43
Fibre per cent	2·29	2·41	2·45	2·40	2·28	2·32	2·35	2·36	0·11	0·14
No. of leaves per ton of fibre	106,070	96,840	96,550	94,070	89,350	89,500	89,520	90,420	10,160	13,830

The results for leaf count are indicating that all treatments were better than the untreated control plots. The variations between the different replications are, however, so big as to obviate any significant difference in the individual treatments, although there is a trend to indicate an increased growth rate when artificial fertilizers are added to the sisal waste. The differences in leaf length are insignificant although the indication for artificials are as in leaf count. The observations for yield figures follow closely on those of leaf count.

ROTATIONAL FERTILIZER TRIAL

Object.—To investigate the effect on sisal of resting the land under grass for a period of years between the cycles with and without a grass cover during the cycle. These treatments are combined with fertilizer treatments on bare land and grass strips between the sisal rows.

Locality.—Anglo-French Sisal Estate, Thika.

Date of Commencement.—24th November, 1952.

Treatments

First Cycle	*Second Cycle*
(1) Clean-weed by frequent discing throughout.	As first cycle.
(2) Plant grass strips, cut grass and mulch along sisal rows.	As first cycle (sisal replanted where grass strips were).
(3) Plant grass strips, cut grass and mulch along sisal rows.	Leave grass strips to cover land for three years; then replant sisal and treat as first cycle.
(4) Clean-weed by frequent discing throughout.	Three years grass ley then as first cycle.

Superimposed on the above treatments are the following fertilizer treatments:—

Control, N, P, Ca, NP, NCa, PCa and NPCa.

Sulphate of Ammonia (*N*).—200 lb. per acre for the first four years of the cycle.

Double superphosphate (*P*).—150 lb. per acre at planting.

Agricultural Lime (*Ca*).—2 tons per acre just before planting.

Design.—Six randomized blocks of four plots each. Each plot split for N, P and Ca (24 plots or 96 split plots).

Planting.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Grass slips were planted in April, 1953, and misses were replanted in November, 1953. The grass has grown well and a good cover which has been obtained does not so far seem to have affected the growth of the sisal. Double superphosphate is the only fertilizer which has caused a significant increase in leaf count and leaf length.

FERTILIZER, WASTE AND GRASS TRIAL

Object.—To investigate the effect of N, P, Ca, and sisal waste on old sisal land with and without grass strips introduced between the sisal lines.

Locality.—Anglo-French Sisal Estate, Thika.

Date of Commencement.—3rd December, 1952.

Treatments.—The following applications were applied singly and in all possible combinations:—

W = Sisal waste.—Collected from a rotary pulp extractor and applied at the rate of 20 tons per acre in 6-ft. strips covering the planting lines.

N = Sulphate of ammonia.—200 lb. per acre applied close to the plants in April, 1953.

P = Double superphosphate.—150 lb. per acre applied as 108 lb. per acre at planting by dropping $\frac{7}{8}$ oz. under each plant. The balance applied in the centre of the wide space between the double rows in April, 1953.

Ca = Agricultural lime.—2 tons per acre applied broadcast on 1st December, 1952.

G = Grass.—Molasses grass (*Melinis minutiflora*), planted as strips between the sisal rows in April, 1953.

Planting.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre)

Designn.—2^5 factorial confounded.

The effect of the five treatments on leaf count and leaf length on the recordings in December, 1954, are given below:—

	Average leaf count of plants without	Average leaf count of plants with	Mean effects
W	56·07	66·22	10·15 (P=0·001)
N	60·33	61·97	1·64 N/S
P	60·55	61·74	1·19 N/S
Ca	59·21	63·09	3·88 (P=0·01)
G	60·67	61·62	0·95 N/S

	Average length of last leaf of plants without *inches*	Average length of last leaf of plants with *inches*	Mean effects *inches*
W	23·58	27·26	3·68 (P=0·001)
N	25·43	25·41	0·02 N/S
P	24·72	26·12	1·40 (P=0·05)
Ca	24·81	26·03	1·22 (P=0·05)
G	24·67	26·17	1·50 (P=0·01)

Sisal waste has produced spectacular results in spite of its low rate of application. It is too early to comment freely on these effects, but they are similar to those obtained during the first two years' growth of the Fertilizer Trial at this station.

Exploratory Fertilizer Trials, Dwa and Zea Estates, Kitale

Object.—To investigate the effect of sisal waste, double superphosphate, sulphate of ammonia and agricultural lime on a soil which has been under sisal for a lengthy period in the Kibwezi and Kitale areas.

Locality.—Dwa Plantations Limited, Kibwezi, and Zea Estates, Kitale.

Date of Commencement.—18th April, 1953, and 9th July, 1953.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments.—Sisal waste at rates of 25, 50 and 100 tons per acre:—

Double superphosphate at rates of—

150 lb per acre at planting;

150 lb. per acre at planting, plus one repetition;

150 lb. per acre at planting, plus three repetitions during the cycle.

Agricultural lime, 2 tons per acre.

The plots are split for an application of sulphate of ammonia.

Design.—2^5 factorial confounded.

At Dwa, the effect of sisal waste at the various rates of application gave the following figures on the average leaf count per plant at December, 1954:—

	Leaves Per Plant
For plots without waste	52.6
For plots with 25 tons waste	58.8
For plots with 50 tons waste	62.5
For plots with 100 tons waste	67.9

The only artificial fertilizer which appears to have had any effect at all is sulphate of ammonia, which has increased the rate of leaf production slightly.

At Zea, it is noticeable that with an average leaf count over the whole trial of 27.9 leaves per plant, the variations between the plots receiving sisal waste at the various rates are as follows:—

	Leaves Per Plant
Average of 8 plots without sisal waste	23.6
Average of 8 plots with 25 tons sisal waste	25.7
Average of 8 plots with 50 tons sisal waste	29.5
Average of 8 plots with 100 tons sisal waste	32.8

At this stage there are no responses to artificial fertilizers.

RATES OF APPLICATION TRIAL

Object.—To ascertain the optimum rates of application of sisal waste, N, P and Ca.

Locality.—High-Level Sisal Research Station, Thika.

Date of Commencement.—10th October, 1954.

Spacing.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Treatments

Fresh sisal waste—

Nil.

25 tons per acre.

50 tons per acre.

Double superphosphate—

Nil.

181.5 lb. per acre (75 lb. P_2O_5).

363.0 lb. per acre (150 lb. P_2O_5).

Sulphate of ammonia—

Nil.

2½ cwt. per acre per annum.

5 cwt. per acre per annum.

Agricultural lime—

Nil.

2 tons per acre.

4 tons per acre.

Design.—3^1 Quasi Latin Square.

This trial is planted on an area, which, after an initial nursery, carried the Cutting Trial for 12 years with an average yield of 5½–6 tons per acre. After the Cutting Trial, the land was heavily infested with "couch", which was controlled chemically by means of TCA before planting a second nursery.

Poor Land Fertilizer Trial

Object.—To attempt to rehabilitate some very poor sisal, three years old growing on exhausted and eroded land.

Locality.—High-Level Sisal Research Station, Thika.

Date of Commencement.—Sisal originally planted March, 1950.

Treatments

Sisal waste.—50 tons after long rains 1953; 50 tons before long rains 1954; 50 tons before long rains 1954 and after removing lower leaves.

Sulphate of ammonia.—300 lb. per acre applied before long rains 1954.

Double superphosphates.—150 lb. P_2O_5 as 365 lb., double superphosphate applied before long rains 1954.

The sisal plants have so far shown no response to the sisal waste applied in 1953. The effect of the waste applied before the long rains in 1954 caused great concern as dark brown sunken spots developed on leaves of some plants, particularly on the under surface, and although the younger leaves and the leaves in the spike appeared undamaged they were in cases severely dwarfed, giving the effect of a "hollow" rather than a "full' heart. There was extensive rotting and pockets of purplish brown dead tissue in some of the boles.

A great deal of investigation was carried out by the Department's Soil Chemist, Plant Pathologist and others and it would appear that heavy and prolonged rain of 8.5 in. in nine days after the application of the waste caused excessively wet conditions close to the boles. As these conditions are abnormal for the sisal plant, damage to some of the boles was sufficient to allow ingress of rotting organisms. This is the first time that this station has seen any ill-effects due to the application of waste.

The only fertilizer which has shown a slight response is sulphate of ammonia, which improved the colour of the plants within a fortnight of application and has to the end of the year increased the rate of leaf production by four leaves per plant but has had very little effect on leaf length.

Exploratory Fertilizer Trials at Voi, Ruiru and Kampi-ya-Moto

The object of the above three exploratory fertilizer trials is to investigate the effect on the growth-rate of sisal by applying fresh sisal waste at rates of 12½, 25 and 50 tons per acre before planting, double superphosphate at the rate of 365 lb. per acre, agricultural lime at the rate of 2 tons per acre and sulphate of ammonia at the rate of 5 cwt. per acre per year for three years in two applications of 2½ cwt. per acre before each rain. The spacing is in all three cases 13 ft × 3ft. × 2 ft. 9 in. (1,980 plants per acre). The Voi trial had a severe setback due to drought. The trials at Ruiru and at Lomolo both grew well, but all three trials are still too young to warrant comment.

Production of Improved Planting Material Trials

Hybrid Variety Trial

Object.—To observe and compare the performance of common sisal with eight promising hybrids received from Mlingano Experimental Station, Ngomeni, Tanganyika Territory.

Date of Commencement.—7th April, 1952,

Planting.—13 ft. × 3 ft. × 2 ft. 9 in.

Design.—3 × 3 balanced lattice. Nine treatments and four replications.

	Leaves grown per plant since planting	Length of last unfurled leaf *inches*
Sisal (*Agave sisalana*) ..	94·6	32·60
Hybrid No.—		
1155	113·5	23·07
1269	158·5	24·61
1300	141·3	28·39
1317	165·6	27·87
1475	134·9	28·07
1660	162·9	30·20
6964	157·2	27·09
7131	161·9	23·23

The high rate of leaf production in the various hybrids as compared with common sisal is clearly demonstrated, but as none of the hybrids has so far produced enough leaves of commercial length over 24 in., no cutting has taken place.

Plant Selection Trial

Object.—To compare common sisal (*Agave sisalana*) with progeny of what has in some cases wrongly ben termed non-flowering sisal.

Date of Commencement.—20th April, 1952.

Planting.—13 ft. × 3 ft. × 2 ft. 9 in. (1,980 plants per acre).

Design.—Six randomized blocks of five treatments.

The results from the recording done in October, 1954, are as follows:—

Treatments		Average No. of leaves grown per plant	Average length of last unfurled leaf *inches*
From a so-called non-flowering plant No. 2 (Carver ex Juja) 3 suckers were collected.	A	193·7	22·91
	B	187·2	23·39
When they poled, bulbils were collecdted and the subsequent nursery plants are here marked	C	206·8	22·76
Suckers from non-flowering plant No. 1 (Everard ex Donyo Sabuk) were planted and marked	D	172·6	29·96
Common sisal is marked	E	96·9	34·46

The higher rate of leaf production in the selected plants is clearly demonstrated but the short leaves produced are of little economic value.

Herbicide Trials

Couch Trial

Object. –To compare the effect on couch of one heavy pre-emergent dressing of TCA with lighter pre-emergent and later post-emergent dressings.

Co-operater.—Messrs. Plant Protection Limited.

Date of Commencement—

Spraying 7th to 8th April, 1954.

Sisal planted 21st April, 1954.

Treatments.—All in 80 gallons of water per acre.

Pre-emergent	*Post-emergent*
80 lb. TCA per acre.	Nil.
50 lb. TCA per acre.	35 lb. TCA per acre.
50 lb. TCA per acre.	20 lb. TCA per acre.
35 lb. TCA per acre.	35 lb. TCA per acre.
35 lb. TCA per acre.	20 lb. TCA per acre.
20 lb. TCA per acre.	20 lb. TCA per acre.
control untreated.	—

Design.—7 × 7 Latin square.

A thick weed cover had developed by the end of August when all broad-leaved weeds and grass, including couch, were slashed off at ground level and weighed. There were indications of the effect of TCA, but the couch control was masked by the invasion of broad-leaved weeds, so all weeds were again cut off at ground level at the end of October and removed. The post-emergent dressings were then applied and it is still too early to assess the results.

Couch and Weed Trial

Object.—To study the effects of adding Methoxone, PCP and a wetting agent to TCA in pre-emergent spraying.

Co-operator.—Messrs. Plant Protection Limited.

Date of Commencement—

Spraying 12th April, 1954.

Sisal planted 21st April, 1954.

Treatments.—All in 80 gallons of water per acre.

(1) 50 lb. TCA per acre.

(2) 30 lb. TCA per acre.

(3) 30 lb. TCA + 5 pints Agroxone 4 per acre.

(4) 30 lb. TCA + (3½ gallons Kanex + 4½ gallons diesel oil) per acre.

(5) 30 lb. TCA + 8 fluid oz. "Agral" L N per acre.

(6) control.

Design.—Four randomized blocks at six treatments.

Weed.—Couch had grown 4–6 in. long, shrubs and tall, broad-leaved weeds were chopped out before spraying.

At the end of August, all broad-leaved weeds were pulled out by hand, and couch and other grasses slashed off at ground level and weighed separately. The distribution of broad-leaved weeds and grasses was uneven over the trial area. On some plots, heavy grass infestation had crowded out broad-leaved weeds, and on others the reverse appeared to have taken place. From preliminary observations the application of Agroxone certainly appeared to have controlled broad-leaved weeds in the initial stages, while the TCA applications again gave a certain amount of couch control. The unevenness of the distribution of the various weeds and grasses has made it difficult to assess the extent of the control exerted by the herbicides. A further application of herbicides was given in the short rains of 1954.

K. LERCHE,
Assistant Agricultural Officer.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (EXPERIMENTS), COAST PROVINCE, 1954

Cassava Variety Trial

A trial was begun at Matuga in the long rains, 1953, with the object of testing the yielding capacity of a number of clones of cassava. These had been introduced to the area in recent years from the E.A.F.F.R.O. Station at Amani. In previous tests here they had been shown to possess promising characteristics; resistance to the virus diseases, mosaic and Brown Streak, satisfactory yielding capacity as judged by field observations, palatability, or, in the absence of a high degree of resistance to disease, the capacity to yield well despite susceptibility. Eight of these recently introduced clones were included in the trial and their yield compared with the popular local clone Boto. The eight concerned were 4315/3, 46106/26, 37312E, 4332/2, 4598/1, C56, 4318/18, and T220. Of these, 37312E is an ordinary cassava and T220 Tree Cassava, and the remainder are Ceara hybrids.

The experiment consisted of three randomized blocks of nine plots. Plot size was 20 yards × 5 yards in which the cassava was spaced in rows 3 ft. apart with a within-the-row spacing of 5 feet. Plants in alternate rows were staggered. All cultivations were on the flat. All plots were harvested in November, 1954, eighteen months after planting. A total of 63 in. of rain fell during the experiment but it was on the whole poorly distributed.

The main results can be summarized as follows:—

Mean Yield of the Clones

Clone	Tons roots per acre	Tons dry chips per acre
4315/3	8·36	2·006
46106/26	17·05	4·026
37312E	8·97	2·060
4332/2	9·69	2·211
4598/1	3·40	0·785
C56	4·54	1·214
4318/18	4·73	1·142
T220	7·32	1·635
Boto	7·00	1·725
Standard error	1·125	0·276
Least significant difference—		
P=0·05	3·37	0·828
P=0·01	4·65	1·142
P=0·001	6·39	1·569

Compared with Boto, the clones 4315/3, 37312E, 4332/2 and T220 give no significantly different yields. 4598/1 is shown to have a substantially lower yielding capacity than Boto, and there is evidence that C56 and 4318/18 are also lower yielders, although the differences in yield between them and Boto are not significant statistically. 46106/26 has been the outstanding clone.

Cotton Variety Trials

An experiment to test the suitability of a number of varieties of cotton for introduction into local cultivation was laid down at three sites, Matuga, Kibarani, and Gede. The varieties tested against the local N17 were C(50)20, UK48 and

S47. The design consisted of randomized blocks with four plots per block. Plot size was 15 ft. × 46 ft.=1/63.13 acres. Spacing was 3 ft. × 2 ft. thinned to two plants per hill.

There were considerable differences in germination capacity between the different varieties. S47 and UK48 both gave consistently good germination, followed by C(50)20, N17 germinated poorly. The following percentages for each variety, recorded at Kibarani, are typical of all three sites: S47, 72 per cent; UK48, 72 per cent; C(50)20, 58 per cent, and N17, 42 per cent. Throughout the growing period the crop remained comparatively free of diseases and pests. A few pink bollworms were seen but other types were almost completely absent. Stainers and jassids were less evident than normally but were still quite numerous. Other pests caused negligible damage. Fungal and bacterial disease was also of comparatively negligible proportions. The order of resistance to jassid with the varieties was (1) UK48 and S47, a possible slight advantage being with the former variety, (2) C(50)20, and (3) N17. The variety S47 was outstanding for early maturity. It started flowering about a week before UK48 and about 10 days before N17. The variety was also ready for picking earlier and a high proportion of the total yield was taken in two early pickings.

The main results of the experiment can be summarized as follows:—

Means of Varieties

	N17	C(50)20	UK48	S47	Least Sig. Differences	
					P=0·05	P=0·01
Total Yield in lb./acre—						
Kibarani	652	1,039	1,326	1,212	434	623
Gede	485	573	612	597	173	
Matuga	259	515	511	447	160	229
Stand in Number of Hills/acre—						
Kibarani	3,018	4,249	5,258	5,227	404	581
Gede	4,419	5,840	6,028	6,016	606	871
Matuga	4,198	5,650	6,395	6,711	614	881

An analysis showed that the error repression for stand on yield was non-significant.

Percentage of A.R. Grade Cotton to Total Yield

	N17	C(50)20	UK48	S47	Least Sig. Difference
					P=0·05
Kibarani	55·8	61·3	57·0	54·8	8·2
Gede	47·8	51·3	46·0	43·0	11·4

UK48 and S47 have outyielded N17 at Kibarani, the former at the 1 per cent point and the latter at the 5 per cent point of probability. C(50)20 just fails to be a significantly better yielder at the 5 per cent point. At Gede, where yields were generally much poorer there was no significant difference between varieties but there is an indication that UK48 and, possibly, also S47 and C(50)20 are better yielders. At Matuga, all three other varieties yielded significantly better than N17, C(50)20 and UK48 at the 1 per cent level of probability. There were no significant differences between percentages of A.R. to B.R. grade cotton with the different varieties.

NPK Exploratory Fertilizer Trials

The 3^3 factorial trials started in 1952 were continued during the year at the Kibarani and Matuga sites. The trial at each site consisted of a single replicate of 27 plots, in blocks of nine plots. Plot size was 1/40th acre, with 3-ft. discards between plots in either direction. At Kibarani, where a new site had been selected for the trial before the long rains, 1953, the treatments were reapplied on the same plots for the long rains, 1954, crop, after failure to obtain responses to the treatments in 1953. The original and reapplied treatments were (1) sulphate of ammonia at 0, 1 and 2 cwt. per acre; (2) double superphosphates at 0, 1 and 2 cwt. per acre; and (3) muriate of potash at 0, $\frac{1}{2}$ and 1 cwt. per acre. The phosphate was placed at planting time and the nitrogen and potash applied in the rows after emergence of the plants. All cultivation was on the flat.

In the long rains crop of Dwarf Hegari sorghum, the main effect of nitrogen was +5.1 cwt. of grain to the acre, and of phosphate +3.5 cwt. per acre, the former increase being significant at the 1 per cent point and the latter at the 5 per cent level of probability.

The main results can be summarized as follows:—

Yield in Cwt. of Grain per Acre

Main effects	With	Without	Significance
N1	17·1	13·3	Least significant differences (at P=0·05) 3·23 (at P=0·01) 4·47
N2	18·4		
P1	16·1	14·6	
P2	18·1		
K1	16·0	15·0	
K2	17·9		

No short rains crop was possible because of the drought.

At Matuga, the trial, started on the present site in 1952, with original treatments as at Kibarani, and reapplication of the nitrogen and potash in 1953, was planted up with *Panicum maximum* in 1954. All three fertilizers were reapplied before planting, all being broadcast. The grass was cut three times during the year and the wilted material weighed. Production was generally poor due to the difficulty of the year and the general low fertility of the site.

In the first cut there was an effect from the higher level of nitrogen which just failed to reach significance at the 5 per cent level of probability. There were also indications of effect from phosphate and potash. The second cut gave significant

responses to phosphate and potash, and the third cut to phosphate only. The results may be summarized as follows:—

YIELDS OF WILTED FODDER PER ACRE

(*cwt. fodder per acre*)

Main effects	With	Without	Significance
1st Cut—			
N1	20·9	20·8	L.S.D. 5 per cent point = 10·1
N2	30·0		
P1	27·6	19·4	L.S.D. at 1 per cent point = 13·9
P2	24·6		
K1	23·1	20·2	
K2	28·4		
2nd Cut—			
N1	16·2	18·8	L.S.D. 5 per cent point = 3·20
N2	20·1		
P1	20·3	14·8	L.S.D. 1 per cent point = 4·43
P2	20·0		
K1	18·0	15·6	
K2	21·5		
3rd Cut—			
N1	10·6	11·2	L.S.D. 5 per cent point = 1·62
N2	11·8		
P1	11·4	9·4	L.S.D. 1 per cent point = 2·23
P2	12·9		
K1	11·0	10·8	
K2	11·9		

Trial of Types of Phosphate on Coastal Soil

A 3[2] factorial trial laid down at Matuga and Shimba Hills in 1953 to compare three types of phosphatic fertilizer guano, Uganda rock phosphate, and double superphosphate, was continued in 1954. The original rates of application had been as follows:—

(*a*) No phosphate, 600 lb. per acre guano, and 816 lb. per acre Uganda rock phosphate (T).

(*b*) No phosphate, 100 lb., and 200 lb. per acre double superphosphate (P).

In 1954, before the long rains planting, repetitive treatments were put on to make the third factor of the factorial trial. These consisted of no phosphate, 600 lb. per acre guano, and 816 lb. per acre of Uganda rock phosphate (R). A long rains and short rains crop was taken at both sites. All cultivations were on 3-ft. tied ridges at Shimba Hills, the ridges having been constructed in 1953 and moulded up in 1954, the fertilizers being placed in the ridges. At Matuga, all cultivation was on the flat.

At Shimba Hills, an attempt was made to establish sorghum as the long rains crop, but this was a failure due to poor growing conditions after planting and the poor quality seed available. Later a green gram crop was established but this grew very badly and yielded a very poor crop. No significant effects of treatments showed up. In the short rains a crop of sorghum was established and, mainly due

to the low rainfall, yielded a light crop. The main results from this crop may be summarized as follows:—

Yield of Grain in Cwt. per Acre

Main effects	With	Without	Significance
T1	6·0	4·8	Least significant difference (at P=0·05) 1·12
T2	5·9		
P1	6·0	5·0	(at P=0·01) 1·52
P2	5·8		
R1	5·6	6·0	
R2	5·1		

The only significant effect to appear is that the original application of guano in 1953 has given a slight significant increase.

At Matuga, a crop of sorghum was established in the long rains and a crop of green gram in the short. Both crops were light due to scarcity of rain and the general low fertility of the site. There were no significant effects of the treatments reflected in the long rains crop, but in the short rains green gram crop the main effect of double superphosphate was a significant increase in yield, and the effect of guano narrowly missed resulting in a significant yield increase.

The results of the Matuga replicate for the long and short rains can be summarized as follows:—

Long Rains—Mean Yield of Sorghum Grain in Cwt. per Acre

Main effects	With	Without	Significance
T1	5·54	6·14	Least significant difference (at P=0·05) 0·98
T2	5·57		
P1	6·25	5·32	(at P=0·01) 1·70
P2	5·68		
R1	6·07	5·29	
R2	5·89		

Short Rains—Mean Yield of Green Gram Seed in Lb. per Acre

Main effects	With	Without	Significance
T1	260	257	Least significant difference (at P=0·05) 18
T2	273		
P1	267	247	(at P=0·01) 24
P2	273		
R1	263	259	
R2	268		

Ridging, Mulching and FYM Trials

The 2^3 factorial trial started at Matuga, Shimba Hills, and Gede in 1952 was continued at the first two sites during the year. The original treatments were 10 tons FYM against none, 3-ft. tied ridges against flat cultivation, and a mulch of dried grass against no mulch. Plots were 1/40th acre in size with 3-ft. vertical

discards and a 6-ft. horizontal discard consisting of a 3-ft. ridge and 3-ft. furrow. Throughout the experiment the ridges have been moulded up, and any deficiency of mulch made up for each crop. No reapplication of FYM has been made at either site.

At Matuga, a crop of sorghum was established in the long rains. This crop, planted at the very beginning of the rains, yielded well. The stand was somewhat thin in places, to a slightly greater extent on the ridged plots than elsewhere. It is concluded that this was due to the drying out of the ridges in the dry period immediately after planting. In the final analysis the main effect of ridges was to cause a depression of 336 lb. per acre in the yield of grain, a depression barely missing significance at the 1 per cent level of probability. The main effect of manure was to cause an increase of yield of 324 lb. per acre, again in this case narrowly missing significance at the 1 per cent point. There was a negative interaction between ridging and mulch of 326 lb. per acre, a figure which again narrowly misses significance at the 1 per cent level of probability. In the short rains a satisfactory crop of green gram was grown, considering the dry weather experienced then. In this crop the main effect of mulch was highly significant, giving an increase of 77 lb. per acre. It is interesting to note that whereas no effect of mulch was evident in the long rains crop, which produced well under satisfactory rainfall, a considerable response to mulch occurred in the poor short rains. There was also evidence of a depression in yield from ridging in the short rains crop, but it missed significance.

The main results from the Matuga replication can be summarized as follows:—

Long Rains—Mean Yield of Sorghum Grain in Cwt. per Acre

	Flat	Ridged	Mean
No Manure ..	13·39	9·29	11·34
Manure	15·18	13·29	14·23
Mean	14·29	11·29	12·79

	No Mulch	Mulch	Mean
No Manure ..	10·14	12·54	11·34
Manure	14·18	14·29	14·23
Mean	12·16	13·41	12·79

	Flat	Ridged	Mean
No Mulch ..	12·21	12·11	12·16
Mulch	16·36	10·43	13·41
Mean	14·29	11·29	12·79

Least significant difference between marginal means—

(at P=0·05)=2·19

(at P=0·01)=3·01

Short Rains—Mean Yield of Green Gram Seed in Lb. per Acre

	Flat	Ridged	Mean
No Manure ..	215·5	189·0	202·2
Manure	218·5	187·5	203·2
Mean	217·0	188·2	202·6

	No Mulch	Mulch	Mean
No Manure ..	155·5	249·0	202·2
Manure	173·0	233·0	203·0
Mean	164·2	241·0	202·6

	Flat	Ridged	Mean
No Mulch ..	173·5	155·0	164·2
Mulch	260·5	221·5	241·0
Mean	217·0	188·2	202·6

Least significant difference between marginal means—
(at P=0·05)=31·4
(at P=0·01)=41·1

At Shimba Hills an attempt was made to establish sorghum in the long rains. This failed, due to bad growing conditions at planting time and the poor quality seed available. The experiment was replanted with green gram. This gave a very poor crop. In the short rains, sorghum was established and a satisfactory crop was obtained, considering the dry conditions. In the long rains, crop manure gave significant increase in yield and mulch gave a somewhat higher increase. No other effects were significant. In the short rains crop the main effects of manure and mulch were again significant and ridging was again without effect. The results from the Shimba Hills replicate may be summarized as follows:—

Long Rains—Mean Yields of Green Gram Seed in Lb. per Acre

	Flat	Ridged	Mean
No Manure ..	85·6	95·2	90·4
Manure	157·2	153·6	155·6
Mean	121·6	124·4	123·2

	No Mulch	Mulch	Mean
No Manure ..	51·2	129·6	90·4
Manure	110·0	200·4	155·2
Mean	80·8	165·2	123·2

	Flat	Ridged	Mean
No Mulch ..	71·2	90·0	80·8
Mulch	171·6	158·4	165·2
Mean	121·6	124·4	123·2

Least significant difference between marginal means—
(at P=0·05)=52·9
(at P=0·01)=72·5

SHORT RAINS—MEAN YIELD OF SORGHUM GRAIN IN CWT. PER ACRE

	Flat	Ridged	Mean
No Manure ..	8·77	8·89	8·83
Manure	16·13	14·16	15·14
Mean	12·45	11·52	11·98

	No Mulch	Mulch	Mean
No Manure ..	6·82	10·84	8·83
Manure	12·58	17·71	15·14
Mean	9·70	14·27	11·98

	Flat	Ridged	Mean
No Mulch ..	9·46	9·94	9·70
Mulch	15·44	13·12	14·28
Mean	12·45	11·52	11·98

Least significant differences between marginal means—
(at P=0·05)=2·65
(at P=0·01)=3·63

Method of Applying Manure and Residual Effects

An experiment was begun at Matuga in the long rains season of 1953 to compare methods of applying FYM and examining residual effects. The experiment consists of four series with thre randomized blocks of six plots in each series, giving a total of 72 plots of 1/40th acre size. The treatments are as follows:—

(*a*) Application of manure: nil; nine tons in the first year; three tons in each of three years.

(*b*) A rotation of four crops; sorghum, followed by beans in short rains, cotton, maize followed by beans in short rains, and cassava.

(*c*) A dressing of fertilizer equivalent in nutrients to the three-ton dressing of manure, applied in each year.

The long rains sorghum crop in Series IV following cassava in 1953, was a poor crop and stand. No treatment effects were evident, even when stand was taken into account in the analysis. The following short rains crop of green gram showed no significant differences either. It too was a very light crop due to the partial failure of the short rains. The cotton crop in Series I following sorghum and beans in 1953 gave highly significant increases for 9 tons FYM applied in 1954, 3 tons manure applied in each year, and the fertilizer equivalents applied each year. There was very little residual affect from the 9-ton dressing of FYM applied in 1953. In Series II the maize was a failure and measurement of effects could be done only by weighing the stover. When this was done it was found that there were marked effects (significant at 1 per cent point) from the 9-ton dressing of FYM applied in 1954 and less marked non-significant increases from the fertilizer equivalents dressing and the 3-ton dressing of FYM applied each year. The advantage, although not marked, was with the fertilizer dressing. Again, only a slight residual effect of the 9-ton dressing of FYM was evident and the resulting increase did not reach significance. In the following green gram crop the pattern was similar, the best treatment being the 9-ton dressing of FYM applied in 1954 followed more closely in this instance by the fertilizer equivalents and the 3-ton dressing of FYM applied each year, all treatments giving significant responses. There was no evidence of a residual effect from the 1953 9-ton dressing of FYM. The cassava crop in Series III has not been harvested to date.

The main results of interest may be summarized as follows:—

Treatment	Mean Yields, Lb. per Acre		
	Seed Cotton	Maize Stover	Green Gram Seed
9 tons manure, 1953	488	3,546	104
9 tons manure, 1954	644	5,280	199
3 tons manure, each year	533	4,393	173
Fertilizer equivalent to 3 tons manure	551	4,867	181
Control	381	2,573	119
Significant difference P=0·05 ..	96	1,515	30
Significant difference P=0·01 ..	137	2,152	43

Rates of Application of Phosphate and FYM

The 3^3 factorial trial, with two replicates, at both Matuga and Shimba Hills, started in 1953, was continued in 1954. In the long rains, 1953, the following treatments were applied:—

(*a*) (M) No manure, 2½ tons per acre, and 5 tons per acre.

(*b*) (P) No phosphate, ½ cwt. per acre, and 2 cwt. per acre double superphosphate.

In the long rains, 1954, at Matuga, the third factor, a repetitive treatment consisting of no phosphate, ½ cwt. per acre, and 1 cwt. per acre double superphosphate (R) was applied. The repetitive treatment at Shimba was no phosphate, 1 cwt. per acre, and 2 cwt. per acre double superphosphate. At both sites the cultivations were on 3-ft. tied ridges, these being moulded up for each crop.

At Shimba Hills there was again difficulty in establishing a sorghum crop and a green gram crop had to be substituted in the long rains. A crop of sorghum was taken at this site in the short rains. The long rains crop was extremely poor whereas the short rains crop was quite satisfactory for the season. In the long rains crop of green gram the 1 cwt. per acre repetitive treatment of double superphosphate gave an increased yield but the higher repetitive gave no such increase. There was no residual effect to the manure or phosphate applied in 1953. The combination of phosphate with repetitive phosphate at the higher levels gave significant depressions in yield compared with lower rates of application. There was a significant negative interaction between manure and phosphate. In the short rains there was again no residual effect of the 1953 applications of manure or phosphate, but a highly significant response to the repetitive applications of phosphate.

At Matuga, the cropping sequence was again green gram in the long rains, owing to failure to establish sorghum, and sorghum in the short rains. The long rains crop was pathetically poor, while again a reasonable short rains crop of sorghum was obtained considering the fertility of these coastal sands and the season. In the long rains crop of gram a significant residual effect of the original ½ cwt. application of double superphosphate was evident in a significant yield increase but the 1 cwt. application gave no effect. The main effect of the repetitive treatment, i.e. double superphosphate applied in 1954, was to give significant increases. There was also a negative interaction between manure and phosphate. No residual effect of manure was evident. All the yields were so small as to be of purely academic interest only. In the short rains, responses in increased yields were obtained for all treatments, but these increases were very small although forming a considerable percentage of the total yield.

The main results for the two sites may be summarized as follows:—

Shimba Hills (*Long Rains*)

Mean Yield of Green Gram Seed in Lb. per Acre

Main effects	With	Without	Significance
M1	119	123	Least significant difference (at P=0·05) 23 (at P=0·01) 31
M2	131		
P1	136	120	
P2	117		
R1	153	115	
R2	105		

(*Short Rains*)

Mean Yield of Sorghum in Cwt. per Acre

Main effects	With	Without	Significance
M1	18·8	18·6	Least significant difference (at P=0·05) 2·8 (at P=0·01) 3·9
M2	18·6		
P1	16·4	18·7	
P2	20·8		
R1	21·6	12·4	
R2	21·9		

Matuga (*Long Rains*)

Mean Yields of Green Gram in Lb. per Acre

Main effects	With	Without	Significance
M1	64	68	Least significant difference (at P=0·05) 8·9 (at P=0·01) 12·1
M2	63		
P1	77	58	
P2	61		
R1	69	53	
R2	73		

(*Short Rains*)

Mean Yields of Sorghum Grain in Cwt. per Acre

Main effects	With	Without	Significance
M1	5·16	4·65	Least significant difference (at P=0·05) 0·52 (at P=0·01) 0·71
M2	5·40		
P1	4·87	4·29	
P2	5·99		
R1	5·61	4·51	
R2	5·63		

Fertilizer Trial with Sugar Cane

The 3^3 factorial trial laid down in December, 1952, was harvested in January, 1954. There were two replicates and the plot size was 1/40th acre, with 6-ft. discards (cropped) between plots. Treatments consisted of (*a*) sulphate of ammonia at 0, 2 and 4 cwt. per acre, applied in the rows four weeks after planting, (*b*) single superphosphate at 0, 2 and 4 cwt. per acre, applied in the furrow at planting time, and (*c*) muriate of potash at 0, 1½ and 3 cwt. per acre also applied in the furrows at planting time. The variety used in the experiment was C0419. Planting was in rows 6 ft. apart, a continuous line of cane being laid with a Don planter.

There was a significant response to 2 cwt. single superphosphate, but no significant further increase for 4 cwt., in yield of cane per acre, yield of sucrose per acre, and in the population of canes per plot. In the percentage purity and percentage sucrose in cane there tends to be a depression through the use of phosphate, not, however, reaching significance in the first instance, but doing so in the case of the percentage sucrose. Increasing the rate of application of single superphosphate from 2 cwt. to 4 cwt. does not cause a further depression in either purity or sucrose content. Nitrogen gave beneficial results in increasing the tonnage of cane per acre, the yield of sucrose, and the population of canes. There was a steady increase in yield for the higher rate of application of sulphate of ammonia and it might well be that higher dressings still would have given economic returns. Nitrogen did not effect the purity or the sucrose content. There was no response to potash. Both phosphate and nitrogen gave the increases recorded, mainly through improving the stand of cane per acre. When correction for stand was made, the consequent analysis showed no differences in yield per acre.

The main results can be summarized as follows:—

A.—Mean Yield of Cane in Tons per Acre

Main effects	With	Without	Significance
N1	42·1	40·8	Least significant differences (at P=0·05) 4·6 (at P=0·01) 5·6 (at P=0·001) 7·7
N2	47·1		
P1	47·7	36·0	
P2	46·2		
K1	40·4	44·9	
K2	44·6		

B.—Mean Yield of Sucrose in Cwt. per Acre

Main effects	With	Without	Significance
N1	133·9	122·1	Least significant differences (at P=0·05) 20·6 (at P=0·01) 28·6 (at P=0·001) 39·4
N2	142·6		
P1	141·0	116·7	
P2	140·9		
K1	129·4	137·9	
K2	131·2		

C.—Mean Yields Corrected to 19,080 Canes per Acre—Tons Cane per Acre

Main effects	With	Without	Significance
N1	42·5	43·0	Least significant differences (at P=0·05) 3·5
N2	44·5		
P1	44·9	41·6	
P2	43·5		
K1	42·4	43·6	
K2	44·0		

D.—Percentage Purity

Main effects	With	Without	Significance
N1	85·4	80·1	Least significant differences (at P=0·05) 6·4 (at P=0·01) 8·9 (at P=0·001) 12·3
N2	81·3		
P1	80·7	85·4	
P2	80·6		
K1	81·4	83·2	
K2	82·2		

E.—Percentage Sucrose in Cane

Main effects	With	Without	Significance
N1	15·8	14·1	Least significant differences
N2	14·4		(at P=0·05)
P1	14·2	15·7	1·3
P2	14·4		(at P=0·01)
K1	14·5	14·9	1·8
K2	14·8		

Fertilizer Trial with Nitrogen, Molasses and Filter Press Mud on Sugar Cane

The randomized block experiment, with six replicates, laid down in December, 1952, was harvested in January, 1954. The treatments tried were: (1) no sulphate of ammonia, molasses, or filter press mud. (N0); (2) sulphate of ammonia at 3 cwt. per acre, (N3); (3) sulphate of ammonia at 6 cwt. per acre, (N6); (4) 3 tons molasses per acre without sulphate of ammonia, (N0M); (5) 3 tons of molasses and 3 cwt. sulphate of ammonia per acre, (N3M); (6) 3 tons molasses per acre and 6 cwt. sulphate of ammonia per acre, (N6M); (7) 10 tons filter press mud without sulphate of ammonia, (N0F); (8) 10 tons filter press mud and 3 cwt. per acre sulphate of ammonia, (N3F); and (9) 10 tons filter press mud and 6 cwt. sulphate of ammonia per acre, (N6F). The molasses were applied four months previous to planting and lightly ploughed in. The filter press mud was heaped and left to weather, being applied prior to planting. The sulphate of ammonia was applied in the rows. Due to the destruction of the first heap of filter press mud by burning by the estate labourers the new heap which had to be made was scarcely mature when it had to be applied. It also meant that planting of the experiment had to be postponed as long as possible in the rains with the result that poor establishment was obtained through the rains tailing off.

The main results of the trial can be summarized in the following tables:—

A.—Mean Yields of Sucrose in Cwt. per Acre

	N0	N3	N6	Least significant differences	
O	98·4	79·2	94·4	(at P=0·05)	29·2
F	127·6	136·0	142·8	(at P=0·01)	40·4
M	83·2	93·2	104·0	(at P=0·001)	55·6

The treatments with filter press mud both alone and in combination have given significant increases in yield. The treatment N6F has given the greatest increase, followed by N3F and then by N0F.

B.—Percentage Sucrose

	N0	N3	N6	Least significant differences	
O	16·54	15·61	15·59	(at P=0·05)	1·50
F	16·72	15·54	14·37	(at P=0·01)	2·02
M	16·79	16·60	15·22	(at P=0·001)	2·68

It can be seen that nitrogen applications have not significantly depressed the percentage when applied alone, but the high level of nitrogen in combination with molasses and filter press mud has done so.

C.—Percentage Purity

	N0	N3	N6	Least significant differences	
O	87·47	85·01	86·14	(at P=0·05)	6·48
F	87·61	85·18	81·96	(at P=0·01)	8·74
M	85·43	86·27	81·54	(at P=0·001)	11·16

Treatments have had no effect on purity.

Matuga Station—Rainfall, 1954

Month	No. days in month	Total rainfall	No. days of rain
		inches	
January	31	Nil	Nil
February	28	1·18	4
March	31	1·66	9
April	30	6·49	13
May	31	7·35	17
June	30	2·06	12
July	31	1·14	11
August	31	1·63	18
September	30	2·05	19
October	31	2·38	8
November	30	1·64	9
December	31	·98	2

Total Rainfall for 1954=28·56 in.

Average Rainfall for 1954=2·38 in.

W. A. WRIGHT,

Agricultural Officer (Exp.) Coast Province.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (EXPERIMENTS), RIFT VALLEY PROVINCE, 1954

Eldoret District

Introduction

Rainfall in 1954 was about normal in its total and very well distributed.

Month	Rainfall in inches	Number of days
January	0·36	3
February	0·03	1
March	0·99	2
April	7·38	14
May	4·08	18
June	6·11	19
July	4·50	20
August	6·10	22
September	4·70	13
October	0·81	5
November	0·16	2
December	3·51	5
Total	38·64	124

No long dry spells were experienced. The skies were usually overcast for most of the day.

Generally, damage by pests and diseases was small to nil, but probably due to the lack of sunlight there was severe lodging of the small grains especially oats. Where complete lodging occurred, secondary growth started and yields were poor.

Experiments

Beans.—A variety trial with five Dolichos Lablab species was laid down on Field B of the Experimental Farm (7,000 ft.) in 1953. The treatments were the following varieties: Black Rongai, White Tambach, Black Meru, Black S.A.O. and Brown S.A.O., tested in a 5 × 5 Latin square with a plot size of 0.0257 acres. Seed was planted by hand at a spacing of 28 × 2 in. on 28th–29th April, 1953, thinned to 28 × 4 in. on 19th May, 1953, and the trial received a basal dressing of 120 lb. double supers per acre drilled with the Planet Junior in the row at sowing time. The experiment was selectively harvested by hand from 17th to 30th November, 1953, and the total rainfall during the growing period was 20.90 in. in 60 days. The results are as follows:—

Summary of Yields, in Lb./Acre

Variety	Mean Yield
	(±24·22) (1)
Black Rongai	360·1
White Tambach	483·8
Black Meru	441·8
Black S.A.O.	485·4
Brown S.A.O.	753·0
Mean	504·8

Significant differences—

	5%	1%	0·1%
(1)	75	105	148

Brown S.A.O. appears by far the highest yielding variety, highly significantly more than any of the other varieties, and if compared with Black Rongai twice as much. These results completely agree with those of the previous year when these varieties were laid down in observations.

Fertilizers.—Two separate fertilizer trials with wheat and oats were carried out on Field B of the Experimental Farm (7,000 ft.) in 1953. The treatments were for both experiments: double supers at 0-75-150 lb. applied by hand in the seed row at planting time, ammonium sulphate at 0-100-200 lb./acre, and muriate of potash (60 per cent K_2O) at 0-75-150 lb./acre; the latter two fertilizers were broadcast by hand as a top dressing about one month after sowing. All 27 treatments were tested in a 3^3 confounded factorial, single replication, in three blocks of nine plots each with a plot size of 0.02523 acres (including guardrows). Both experiments were located close to each other, on a typical shallow Uasin Gishu profile with orange brown loam over orange dark red and black mottled solid murram at 14 in., over weathering phonolite. Seed was drilled with the Planet Junior in 8-in rows, dressed with Agrosan and D.D.T. and harvested and threshed by hand. The particular site was ploughed up from natural veld in 1951 and planted with wheat in 1952 with 100 lb. double supers per acre.

Results are as follows:—

Wheat.—this trial was planted with 294M wheat at 80 lb./acre on 20th June, 1953, both fertilizer top dressings were broadcast on 28th July, 1953, and all plots harvested from 7th to 10th November, 1953. During this period, rainfall amounted to 13.3 in. in 38 days.

SUMMARY OF YIELDS, IN LB./ACRE

		Muriate of Potash 0	75	150	Mean
			(±41·74) (1)		(±24·10) (2)
Double Supers ..	0	523·9	631·7	580·8	578·8
	75	640·7	691·6	758·9	697·1
	150	667·6	735·0	899·6	767·4
		Sulphate of Ammonia 0	100	200	
Double Supers ..	0	591·3	537·4	607·7	
	75	711·0	705·0	675·1	
	150	745·5	764·9	791·9	
Muriate of Potash ..	0	589·8	621·2	621·2	610·7
	75	655·7	691·6	711·0	686·1
	150	802·3	694·6	742·5	746·5
			(±24·10) (2)		
Mean		682·6	669·1	691·6	681·1

Significant responses—

	5%	1%	0·1%
(1)	126	174	240
(2)	73	100	139

ANALYSIS OF SOIL SAMPLES (18–6–53)

Block	pH	W. & B. organic C%	N%	C/N ratio (corrected)	EXCHANGEABLE BASES ME%			
					Cap.	Tot.	Ca	% Sat.
I ..	5·9	1·65	0·17	13	11·9	7·9	4·7	66
II ..	5·9	1·65	0·14	16	12·9	8·8	5·9	68
III ..	5·5	1·59	0·17	12	12·3	7·2	1·9	59

Double supers alone increase yields 1 per cent significantly with the middle rate and to a 0.1 per cent level with the high rate though the increase due to doubling the rate is not significant. Ammonium sulphate alone does not influence yield level. Muriate of potash alone does increase yields 5 per cent significantly with the middle rate whilst double this rate does not give a significant extra increase though, compared with no potash the increase is 0.1 per cent significant. Of all interactions, only phosphate × potassium interaction is of interest: significant increases are obtained with the highest rates interaction compared with either phosphate or potassium alone. The absolute yield level is low due to the poor rainfall.

Oats.—This trial was planted with Grey-Algerian oats at 72 lb./acre on 19th May, 1953, both fertilizer top dressings were broadcast on 27th July, 1953, and all plots harvested from 4th to 7th November, 1953. During this period rainfall amounted to 17.50 in. in 49 days.

SUMMARY OF YIELDS, IN LB./ACRE

		Muriate of Potash 0	Muriate of Potash 75	Muriate of Potash 150	Mean
			(±77·78) (1)		(±44·91) (2)
Double Supers ..	0	1029·9	1058·3	992·5	1026·9
	75	1002·9	1103·2	1092·8	1066·3
	150	1082·3	1101·7	1089·8	1091·3
		Sulphate of Ammonia 0	Sulphate of Ammonia 100	Sulphate of Ammonia 200	
Double Supers ..	0	1137·7	1073·3	869·7	
	75	1227·5	998·4	973·0	
	150	1270·9	1083·8	919·1	
Muriate of Potash ..	0	1252·9	1013·4	848·8	1038·4
	75	1176·6	1050·8	1035·9	1087·8
	150	1206·5	1091·3	877·2	1058·3
			(±44·91) (2)		
Mean		1212·0	1051·8	920·6	1061·5

Significant responses—

	5%	1%	0·1%
(1)	234	324	448
(2)	135	187	259

Analysis of Soil Samples (18–6–53)

Block	pH	W. & B. organic C%	N%	C/N ratio (corrected)	Exchangeable Bases ME%			
					Cap.	Tot.	Ca	% Sat.
I ..	5·5	1·59	0·14	15	12·2	7·9	2·5	65
II ..	5·7	1·66	0·13	16	12·1	8·0	4·2	66
III ..	5·6	1·51	0·16	13	14·0	8·8	3·2	63

Results are erratic due to the unfavourable distribution of the rainfall. Double supers alone increased yields though with neither of the two rates any significant level is obtained. Ammonium sulphate alone decreases yields to a 5 per cent level with the middle rate, down to 0.1 per cent with the high rate whilst the decrease obtained by doubling the middle rate nearly becomes 5 per cent significant. Muriate of potash increases yields in an erratic way and not significantly. Of all interactions, only nitrogen × phosphate interaction is of interest because any increase due to phosphates is offset by the negative influence of nitrogen. Yields of nitrogen × phosphate treatments are significantly less than those with phosphate alone.

An experiment to determine the residual and cumulative effects of phosphate with wheat laid down on field A of the Experimental Farm (7,000 ft.) in 1952, was continued in 1953. The treatments are:—

(1) Uganda rock applied in first year only.

(2) Uganda rock applied in first and second years.

(3) Uganda rock in first, second and third years.

(4) Soda phosphate in first year only.

(5) Soda phosphate in first and second years.

(6) Soda phosphate in first, second and third years.

(7) Double supers in first year only.

(8) Double supers in first and second years.

(9) Double supers in first, second and third years.

The rates of the three fertilizers are: Double supers (40.8 per cent citric soluble P_2O_5) at 206, soda phosphate (18 per cent) at 466 and Uganda rock (3.6 per cent) at 816 lb. per acre. All nine treatments and one control (no phosphate) were tested in a (10 × 10) Latin square with a plot size of 0.0193 acres (including guard rows).

All fertilizers were drilled by hand in 8-in. rows at planting time, and the whole trial was sown with 284M wheat at 80 lb./acre with the Planet Junior (dressed with Agrosan and D.D.T.) on 6th to 7th July, 1953, and harvested by hand on 15th to 16th December, 1953. Rainfall during this period was 12.59 in. in 35 days.

Summary of Yields, in Lb./Acre

Treatment	Mean yield	Responses
	(±18·78 for single treatments) (±13·28 for combined treatments)	(±26·56 for single treatments) (1) (±23·00 for combined treatments) (2)
No phosphate	52·4	—
Uganda Rock in 1st year (1952)	93·5	41·1
Uganda Rock in 1st and 2nd, and 1st, 2nd and 3rd years	56·3	3·9
Soda phosphate in 1st year	143·1	90·7
Soda phosphate in 1st and 2nd, and 1st, 2nd and 3rd years	180·6	128·2
Double Supers in 1st year	153·8	101·4
Double Supers 1st and 2nd, and 1st, 2nd and 3rd years	240·3	187·9

Significant responses—

	5%	1%	0·1%	
(1)	53	71	92	
(2)	46	61	80	
(3)	70	93	122	between single and combined treatments.

Probably, owing to the poor rainfall, responses are erratic, especially with regard to Uganda rock and to a lesser extent Soda phosphate. The residual effect of Uganda rock of one year is of great magnitude compared with its residual and immediate effects but in neither of the cases any significant level is obtained. Also there is no significant difference between residual and residual and immediate effects. Soda phosphate shows a considerable residual effect from the first year which is nearly 0.1 per cent significant. The residual and immediate effects together are 0.1 per cent significant but the difference between these two effects is not significant. The residual effect of double supers of one year is of about same magnitude as soda phosphate but its residual and immediate effects are considerable and the difference of residual *vs.* residual and immediate effects is 5 per cent significant.

Grass.—Two ley establishment trials were started on Field B of the Experimental Farm in 1953, and continued in 1954. Treatments and designs which were identical for both trials were as follows: (*a*) wheat planted alone as normal (7-in. rows), (*b*) ley broadcast in pure stand, (*c*) ley established under wheat which is drilled in 7-in. rows, and (*d*) ley established under wheat which is drilled in 14-in rows. In 1954, the pure wheat plots of 1953 (treatment (*a*)) were broadcast with the mixture.

All treatments were tested in six randomized blocks of four plots each. Wheat (294M) was mechanically planted with the drill at 85 lb./acre for both spacings and was dressed with Agrosan and D.D.T.

A basal dressing of 1 cwt. double supers per acres was broadcast by hand prior to sowing and again in 1954, and a basal dressing of 1½ cwt. ammonium sulphate per acre as top dressing was broadcast in 1954, but not in 1953 because of the low rainfall.

The trials were:—

(*a*) *Nandi Setaria* (Setaria sphæcelata ex Nandi) *with Stylosanthes gracilis and Alysicarpus glumaceus.*—Wheat was drilled on 13th July, 1953, and the grass (20 lb./acre) and both legumes (each at 5 lb./acre) broadcast by hand on 15th July, 1953. The mixture was again sown on 4th May, 1954. On treatment (*a*), double supers were applied on 13th July, 1953, and 22nd April, 1954, and ammonium sulphate on 28th July, 1954. The plot size was 0.01326 acres, and the rainfall amounted in 1953 to 12.66 in. in 37 days and in 1954 to 34.97 in. in 114 days. Owing to the low rainfall in 1953, growth of the ley and wheat were poor. In 1953, no grass clippings could be obtained but, in 1954, three cuts were done respectively on 9th June, 1954 (except treatment (*a*)), 26th to 27th July, 1954, and 5th to 6th October, 1954. The wheat was harvested on 9th December, 1953, and threshed by hand.

Summary of Wheat Yields, in Lb./Acre

Treatments	Mean seed yield
	(±5·52) (1)
Wheat planted alone in 7-in. rows	82·9
Undersown wheat at 7-in. spacing	84·6
Undersown wheat at 14-in. spacing	84·6
Mean	84·1

Summary of Grass Clipping Yields (Fresh) in Tons/Acre

Treatment	Mean Yield		
	9–6–54	26/27–7–54	5/6–10–54
	(±0·39) (2)	(±0·32) (3)	(±0·30) (4)
Pure wheat in 1953 sown to ley in 1954..	—	1·7	6·5
Ley in pure stand sown in 1953	3·4	2·4	4·7
Ley sown under 7-in. wheat	0·7	3·2	3·6
Ley sown under 14-in. wheat	0·5	3·0	3·4
Mean	1·5	2·6	4·5

Significant differences—

	5%	1%	0·1%
(1)	17	25	—
(2)	1·2	1·7	2·5
(3)	1·0	1·3	1·8
(4)	0·9	1·3	1·7

Owing to the poor rainfall in 1953, especially in the later stages of development, wheat yields are extremely low. If wheat either in 7-in. or 14-in. spacings is undersown with the mixture, seed yields are not decreased compared with wheat not undersown.

With regard to fresh grass yields, of the first cutting the pure ley sown in 1953 yields are about six times more (=0.1 per cent significant) than each of both undersown treatments. There are no significant differences between

the two spacings of the undersown treatments and this is also repeated in the next cuttings. However, in the other two cuttings the yield of the pure ley sown in 1953 is of about the same magnitude compared with the undersown treatments. But the pure ley sown in 1954 yields more than any of the other treatments in the last two cuttings.

If compared on a grand total basis, however, the pure ley of 1953 is superior to the remaining treatments which are roughly of same order. The beneficial effects of a nitrogen top dressing (28th July, 1954) are very well expressed in the mean yields.

(*b*) *Molasses grass* (Melinis minutiflora) *with Provence lucerne inoculated*).—Wheat was drilled on 15th July, and the grass (15 lb./acre) and lucerne (5 lb./acre) broadcast by hand on 18th July, 1953. This mixture was again sown on treatment (*a*) on 4th May, 1954. Double supers were applied on 13th July, 1953, and 22nd April, 1954, and ammonium sulphate on 29th July, 1954. The plot size was 0.02062 acres, and the rainfall amounted in 1953 to 12.66 in. in 37 days, and in 1954 to 34.97 in. in 114 days.

Owing to the low rainfall in 1953, growth of the ley and wheat were poor. In 1953, no grass clippings could be obtained but, in 1954, two cuts were done respectively on 21st to 22nd June (except (*a*)) and 6th to 7th October, 1954. The wheat was harvested on 9th December, 1953, and threshed by hand.

SUMMARY OF WHEAT YIELDS IN LB./ACRE

Treatments	Mean seed yield
	(±7·54) (1)
Wheat planted alone in 7-in. rows	82·0
Undersown wheat in 7-in. rows	75·1
Undersown wheat in 14-in. rows	79·0
Mean	78·7

SUMMARY OF GRASS CLIPPING YIELDS (FRESH) IN TONS/ACRE (1 TON=20 CWT.)

Treatment	21/22–6–54	6/7–10–54
	(±0·22) (2)	(±0·55) (3)
Pure wheat in 1953, sown to ley in 1954	—	6·4
Ley in pure stand sown in 1953	5·1	4·6
Ley sown under 7-in. wheat	2·7	4·4
Ley sown under 14-in. wheat	2·9	4·9
Mean	3·6	5·1

Significant differences—

	5%	1%	0·1%
(1)	24	34	—
(2)	0·7	1·0	1·4
(3)	1·7	2·3	3·2

Owing to the low rainfall in 1953, especially in the later stages of growth, wheat yields are extremely poor. Under-sowing wheat, either in 7-in. or 14-in. spacings, did not significantly decrease seed yields.

With regard to fresh grass yields, in the first cutting the pure ley sown in 1953 yields nearly twice as much as both undersown treatments which do not differ significantly. In the second cutting, however, there are no significant differences between these three treatments, but these are outyielded positively to a 5 per cent significant level by the pure ley sown in 1954.

However, taken on a grand total basis, the pure ley sown in 1953 is superior to any of the other treatments which are roughly of the same magnitude.

The beneficial effects of the nitrogen top dressing (29th July, 1954) are very clearly noticeable in the mean yields.

Nakuru District

Introduction

It has been a good year for rainfall. Figures for selected stations are given below.

1954 Month	Rongai		Londiani		Njoro	
	Days of rain	Rainfall in inches	Days of rain	Rainfall in inches	Days of rain	Rainfall in inches
January ..	2	0·20	4	1·27	—	—
February ..	1	0·01	3	0·64	5	0·70
March ..	3	0·46	3	0·22	4	0·24
April ..	18	5·32	20	6·78	23	9·25
May ..	28	13·50	24	6·56	24	9·64
June ..	16	7·88	15	1·97	21	6·17
July ..	19	6·89	17	6·35	22	6·05
August ..	13	3·90	18	4·79	14	3·04
September	7	3·94	12	3·84	22	6·05
October ..	10	1·40	11	1·58	9	1·94
November	11	1·01	3	0·53	14	3·05
December	3	0·57	4	0·43	5	0·35
Total ..	131	45·08	134	34·96	163	46·48

Experiments

Entomology.—As a result of an observation, in which different insecticides were applied as a control against the barley bulb fly, and in which trial aldrin appeared to be superior to any of the other materials, it was decided to carry out an experiment on Crater Stream Farm at Solai.

The treatments were four rates of Aldrin 40 per cent wettable powder, 0-12-16 and 20 oz. per 100 lb. of seed, in interaction with four barley varieties, Herta, Research, Abed Kenia and Prior. All treatments were tested in four randomized blocks of 16 plots each, with a plot size of 0.0145 acres. The trial was planted on 20th July, 1954, and plant counts were made by selecting two areas of one

square yard at random and counting both healthy and infected plants within that area. The results are as follows:—

Rate of Aldrin*	Percentage Infected Plants				Mean
	Herta	Research	Abed Kenia	Prior	
		(±3·25) (1)			(±1·63) (2)
0 oz. 40 per cent W.P.	27·9	26·3	26·4	25·8	26·6
12 oz.	17·1	7·3	7·0	14·9	11·6
16 oz.	5·5	17·0	13·1	7·3	10·7
20 oz.	4·8	6·7	5·8	11·7	7·3
		(±1·63) (2)			
Mean	13·8	14·3	13·1	14·9	14·0

*per 100 lb. of seed.

Significant differences—

	5%	1%	0·1%
(1)	9·3	12·4	16·3
(2)	4·7	6·2	8·2

There is a highly significant decrease of infected plants with an increase of rates of Aldrin. There are no significant differences in percentage of infection between any of the varieties.

Two fertilizer trials comparing various types of nitrogenous fertilizers with wheat on red—(F. Keppie's Farm) and vlei-soils (G. Robson's Farm) at Londiani (7,500 ft.) were undertaken in 1953. In both cases treatments and designs were identical. The former were:—

(*a*) Sodium nitrate at 276 lb./acre,

(*b*) sodium nitrate plus slaked lime at 90 lb./acre,

(*c*) ammonium sulphate at 208 lb./acre,

(*d*) ammonium sulphate plus slaked lime at 90 lb./acre,

(*e*) calcium cyanamide at 208 lb./acre,

(*f*) nitrochalk at 276 lb./acre,

(*g*) calcium nitrate at 276 lb./acre,

with a control (no nitrogenous fertilizers) making eight treatments in total tested in five randomized blocks of eight plots each with a plot size of 0.02479 acres including guard-rows.

Sodium and calcium nitrate were broadcast by hand as top dressings three weeks after planting, nitrochalk after emergence, calcium cyanamide and slaked lime 5–10 days before planting, and ammonium sulphate at sowing time. In each trial a basal dressing of 100 lb. double supers per acre was drilled with the seed at planting time and the plots were harvested by combine.

On the red soil, 294M wheat was planted on 17th June, 1953, and harvested on 15th December, 1953. The rainfall during this period amounted to 15.63 inches in 69 days.

SUMMARY OF YIELDS IN LB./ACRE

Treatments	Mean yield	Response
	(±117·38) (1)	(±166·00) (2)
Control	848·9	—
Ammonium Sulphate and lime	893·5	44·6
Calcium Nitrate	927·0	78·1
Ammonium Sulphate	1038·7	189·8
Calcium Cyanamide	1061·1	212·2
Nitrochalk	1072·2	223·3
Sodium Nitrate	1072·2	223·3
Sodium Nitrate and Lime	1128·1	279·2

Significant responses—

	5%	1%
(2)	340	459

The increases due to the application of nitrogenous fertilizers are not significant.

On the vlei-soil 1066 wheat was planted on 6th June, 1953, and harvested on 16th December, 1953. The rainfall during this period amounted to 20.28 in. in 79 days.

SUMMARY OF YIELDS IN LB./ACRE

Treatments	Mean yield	Response
	(±91·99) (1)	(±130·09) (2)
Control	1,358·9	—
Ammonium Sulphate and Lime	1,461·3	102·4
Calcium Nitrate	1,489·2	130·3
Ammonium Sulphate	1,535·7	176·8
Sodium Nitrate	1,554·4	195·5
Calcium Cyanamide	1,573·0	214·1
Sodium Nitrate and Lime	1,582·3	223·4
Nitrochalk	1,610·2	251·3
Mean	1,520·6	

Significant responses—

	5%	1%
(2)	266	359

The increases due to the application of nitrogenous fertilizers are not significant.

Kitale District

Introduction

The rainfall in 1954 was 46.94 in., 1.58 in. above the average for the past 20 years. The distribution was, on the whole, good except the three weeks drought in April and a further three weeks in May. July, August and September were cold, overcast and wet, while October was unexpectedly dry.

Month	Rainfall in inches	Number of days
January	0·42	4
February	2·17	7
March	3·09	3
April	6·07	14
May	5·39	22
June	4·62	15
July	6·99	18
August	7·71	24
September	7·18	14
October	0·84	9
November	1·19	4
December	1·27	9
Total	46·94	143

Experiments

Oilcrops.—A spacing trial of giant *vs.* dwarf sunflowers with nitrogenous and phosphatic fertilizers was laid out on Field F of the Experimental Station at Kitale (6,200 ft.) in 1953. The site was broken from veld in 1952, planted with sunflowers and the green produce ploughed in. The soil-type is a red brown coarse sandy loam over red loam to fine sandy clay loam derived from gneiss. The treatments were as follows:—

(*a*) two varieties: giant (Giant White) *vs.* best dwarf variety (Mars);

(*b*) two spacings between rows: 18 and 30 in.;

(*c*) four spacings in the row: 6, 9, 12 and 18 in.

(*d*) two rates of double supers: 0-150 lb./acre:

(*e*) two rates of ammonium sulphate: 0-1½ cwt./acre, tested in a 4×2^4 confounded factorial, single replication, in eight blocks of eight plots each with a plot size of 0.03443 acres including guard rows. Both fertilizers were drilled by hand in the row at planting time (12th to 13th June, 1953), the seed was planted thickly, thinned by hand from 19th to 22nd July and harvested by hand from 21st to 28th October (dwarf) and from 25th November to 4th December, 1953 (giant). The rainfall during this period was 45 in.

Below are two tables giving yields for optimal spacings for both varieties:—

	Giant White, 30 × 18 in. Ammonium Sulphate 0 cwt.	Giant White, 30 × 18 in. Ammonium Sulphate 1½ cwt.	Mean
		(±50·41) (1)	(±35·65) (2)
Double Supers 0 lb.	696·9	696·9	696·9
Double Supers 150 —	816·6	925·5	871·1
		(±35·65) (2)	
Mean	756·8	811·2	784·0

There is an estimated loss of 25 per cent due to shattering and birds.

	Mars, 18×12 in. Ammonium Sulphate 0 cwt.	Mars, 18×12 in. Ammonium Sulphate 1½ cwt.	Mean
	(±50·41) (1)		(±35·65) (2)
Double Supers .. .. 0 lb.	580·6	707·8	644·2
150 —	943·8	970·8	957·3
	(±35·65) (2)		
Mean	762·2	839·3	800·7

Significant differences—

	5%	1%	0·1%
(1)	148	201	270
(2)	105	142	191

Summary of Results.—Generally speaking, for both varieties there is a significant increase in yield due to phosphate alone. Yields are increased with nitrogen alone but not significantly.

Nitrogen and phosphate together increase yields to a 0.1 per cent level though, if compared with phosphate alone, no significant difference is obtained. The yields for both varieties are low.

Stock Feeding Trials.—A trial to find out whether milking cows can take in more dry matter, and hence yield more milk, by mowing and wilting their grazing beforehand or by giving access to hay, was carried out at Kitale Experimental Station. Three groups of five Guernsey cows each were selected at random from 15 cows at roughly the same stage of lactation and having similar yields. Each group passed through each of three treatments in turn which were separated by introductory periods of five-seven days, whereas the actual trial period lasted 20 days. The treatments were—

(*a*) normal grazing;

(*b*) normal grazing with hay on paddock;

(*c*) mowing and wilting before grazing.

Treatment (*c*) was done at 7 a.m. each day, allowed to wilt for four hours and fed at 11 a.m. each morning. The particular site, field 23B, was a third-year ley of molasses, and Rhodes grasses with molasses grass very dominant. The trial started on 13th May, and lasted until the end of October. In the first stage the trial was conducted with a basal feeding of concentrates, but from 7th August onwards it was repeated without that basal ration. The results are as follows:—

SUMMARY OF YIELDS IN LB. OF MILK

Treatment	WITH CONCENTRATES			WITHOUT CONCENTRATES		
	morning	evening	daily total	morning	evening	daily total
	(±0·23) (1)	(±0·16) (2)	(±0·37) (3)	(±0·32) (4)	(±0·25) (5)	(±0·51) (6)
Normal grazing	7·4	5·4	12·8	7·3	5·7	13·0
Normal grazing and hay..	7·6	5·5	13·2	6·6	5·6	12·2(
Mowing and wilting ..	7·2	5·6	12·8	6·7	5·4	12·1
Mean	7·4	5·5	12·9	6·8	5·6	12·4

Significant differences—

	5%	1%
(1)	0·7	0·9
(2)	0·5	0·6
(3)	1·1	1·4
(4)	0·9	1·3
(5)	0·7	1·0
(6)	1·5	2·0

Summary of Results.—There are no significant differences between any of the treatments though without concentrates treatments (*b*) and (*c*) decrease milk yields slightly.

A trial to assess the value of feeding the antibiotic "Aurofac" to pigs being fattened for bacon, started at the Kitale Experimental station in 1953, and was successfully concluded in 1954. The breed concerned was Large White, and skimmed milk at 15 gallons per head plus bloodmeal were included in the normal ration (=N). Total number of pigs involved were 43, and the number participating in each treatment was generally four.

TREATMENT		Average weaning weight in lb.	Average days to fatten	Average daily live weight gain	Conversion ratio	Average profit per pig in Sh.	Mean grading	Mean percentage transit loss
weaning to 120 lb.	120–220 lb.			(±0·05) (1)	(±0·08) (2)	(±12·89) (3)		
N	N	48	117	1·51	3·50	80·3	VF1ABAA	28·67
N	N+⅛%	44	135	1·31	3·62	93·9	VF1ABAA	28·13
N	N+¼%	44	140	1·30	3·60	94·1	VF1ABAA	25·99
N+⅛%*	N	39	142	1·24	3·61	68·8†	F1AABA	25·15
N+⅛%	N+⅛%	40	138	1·34	3·79	89·6	VF1ABAA	24·09
N+⅛%	N+¼%	45	120	1·51	3·26	22·8	VF1ACCC	28·89
N+¼%	N	48	117	1·56	3·19	93·1	F1ABBB	26·67
N+¼%	N+⅛%	41	133	1·35	3·40	39·1‡	FF1BCCC	27·80
N+¼%	N+¼%	40	138	1·37	3·28	84·4	F1BBBC	28·84
	Mean	43	131	1·39	3·47	74·0		

*Percentage Aurofac.
†High food costs.
‡Poor grading due to progeny of doubtful sow.

Significant differences—

	5%	1%	0·1%
(1)	0·14	0·19	0·26
(2)	0·24	0·34	—
(3)	39	53	73

Summary of Results.—Addition of Aurofac reduced the conversion ratio, increased profitability and did not affect the quality of the carcass if applied moderately. The latter chiefly depends on genetics and good feeding level in the first instance. The best conversion ratio was obtained from treatments with $\frac{1}{4}$ per cent Aurofac up to 120 lb. liveweight followed by absence or presence of the antibiotic in the second stage. The best profitability and grading were obtained from $\frac{1}{8}$ or $\frac{1}{4}$ per cent in the second stage or $\frac{1}{4}$ per cent in the first stage only.

Normal feed with $\frac{1}{4}$ per cent Aurofac up to 120 lb. liveweight and finishing off on normal feed is considered the most satisfactory treatment though there is a small drop in quality, but the latter can still be considered fair to good. Differences in profitability are, on the whole, small and it would hardly seem worth while to add Aurofac to the meal but this is probably due to the inclusion of skimmed milk and bloodmeal in the basal ration. However, application of Aurofac to runt pigs (which are normally killed before weaning) appears more profitable, since these can be fattened to bacon weight economically.

Ol Joro Orok District

Introduction

The following table shows the rainfall recorded at the Experimental Farm (7,800 ft.) and is compared with the average monthly and total figures for the previous eight years:—

Month	Rainfall 1954 in inches	Average 1946–53 (inclusive)
January	0·08	0·35
February	0·33	0·37
March	0·07	1·90
April	3·61	5·66
May	6·31	4·50
June	4·45	3·40
July	8·41	5·06
August	4·22	6·80
September	6·02	2·90
October	1·74	2·13
November	0·51	1·62
December	1·04	2·03
Total..	36·79	36·72

The rainfall figures for the first quarter show that the district generally had suitable weather for the completion of the harvest and the initial preparation of lands for planting. However, at sowing time rainfall was fairly continuous and growth of plants appeared slow, but generally fair average crops of cereals have been realized.

Experiments

Fertilizers.—The trial to determine the residual and cumulative effects of phosphate with barley, started in 1952 on the station, was continued in 1953. Treatments and rates of fertilizers are similar to those of the trial at Eldoret (*see* above), and are also grouped in a (10 × 10) Latin square with a plot size of 0.01240 acres including guard-rows. All phosphates were broadcast by hand immediately prior to planting on 10th July, 1953, and the trial was mechanically

drilled with Spratt Archer barley at 60 lb./acre in 8-in. rows on 11th July, 1953, and harvested by hand from 21st to 29th December, 1953. The rainfall during this period was 15.29 in. in 71 days. The particular site received a basal dressing of 50 lb. in 1950, and 75 lb. double supers per acre in 1951.

The results obtained may be summarized as follows (2nd year of trial):—

SUMMARY OF YIELDS IN LB./ACRE

Treatment	Mean yield	Responses
	(±54·64 for single treatments) (±38·64 for combined treatments)	(±77·27 for single treatments) (1) (±66·92 for combined treatments) (2)
No phosphate (control)	456·8	—
Uganda Rock in 1st year (1952)	429·0	−27·8
Uganda Rock in 1st and 2nd, and 1st, 2nd and 3rd years	410·4	−46·4
Soda phosphate in 1st year	310·8	−146·0
Soda phosphate in 1st and 2nd, and 1st, 2nd and 3rd years..	385·1	−71·7
Double Supers in 1st year..	367·9	−88·9
Double Supers in 1st and 2nd and 1st, 2nd and 3rd years	496·7	39·9

Significant responses—

	5%	1%	0·1%	
(1)	155	206	267	
(2)	134	178	232	
(3)	204	272	354	between single and combined treatments.

Summary of Results.—In all cases, responses are negative except in one treatment with double supers. In one treatment with soda phosphate the negative response nearly becomes 5 per cent significant. Results are of an erratic nature because rainfall adversely affected yields.

An experiment to determine the effects of fertilizers in conjunction with time of application to newly broken veld on the following wheat crop was undertaken at the Experimental Station in 1953. The treatments were as follows:—

(*a*) Double supers: 0-100-200 lb. per acre (A-B-C).

(*b*) Ammonium sulphate: 0-2-4 cwt./acre (D-E-F).

(*c*) Time of application of fertilizers—

(1) early to fallow land (26th May, 1953) (G);

(2) late to wheat (29th June, 1953) (H);

(3) Half to fallow (26th May), half to wheat (29th June) (I), grouped in a 3^3 confounded factorial, single replication, in three blocks of nine plots each with a plot size of 0.02755 acres. Both fertilizers were broadcast by hand, the trial was mechanically drilled with Ceres 64 wheat at 75 lb./acre in 8-in. rows on 29th June, 1953, and all plots harvested by combine on 16th December, 1953. The rainfall during this period was 16.23 in. in 73 days. The experimental site was ploughed up from veld in 1953. There were no significant responses to any treatments.

Stock Feeding Trial.—A trial to determine whether dairy cows are able to obtain an adequate intake of dry matter, run along similar lines as at Kitale (*see* above), was carried out at the Experimental Station.

Three groups of four Ayrshire cows, each of about equal milking potential, were subjected to three different treatments for four weeks after an introductory period. The treatments were:—

(*a*) Normal grazing.

(*b*) Normal grazing plus straw.

(*c*) Grass mown early in the morning and allowed to wilt before feeding. Each treatment started grazing at 11 a.m. each day after treatment (*b*) had consumed its straw. The particular site was a Bromus-Kikuyu ley yielding 3,025 lb. dry matter per acre (moisture content 9.6 per cent). The trial started on 2nd August, 1954, and no basal feeding of concentrates was given.

TOTAL DAILY MILK YIELD IN LB.

Treatment	Mean yield
	(±0·86) (1)
Normal grazing	12·8
Normal grazing plus straw	13·3
Grass mown and wilted	11·7
Mean	12·6

Significant differences—

	5%	1%
(1)	3	4·5

Treatment differences were not significant.

E. BOSWINKLE,
Agricultural Officer (Exp.) Rift Valley Province.

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (EXPERIMENTS), CENTRAL PROVINCE, 1954

Rainfall

	Embu	Molinduko
January	Nil	
February	0·21	
March	0·95	
April	16·88	
May..	17·67	
June..	1·38	
July	1·75	
August	0·73	
September	1·02	0·06
October	6·34	6·2
November	5·33	7·63
December	2·52	1·85
Totals	54·76	15·74

Overall weather conditions for the whole of 1954 have been extremely favourable with both adequate and evenly distributed rainfall.

Reports on Experimental Work

(1) High Bracken Zone

Exploratory Fertilizer and Farmyard Manure Trial.—This trial was undertaken to test the effects of applications of phosphate, nitrogen and farmyard manure on crop yields in this area which is characterized by extremely poor soils and a high rainfall. Farmyard manure applied at 10 tons per acre was compared with nil combined with double superphosphate applied at 2 cwt. per acre versus nil, and with sulphate of ammonia applied at 2 cwt. per acre versus nil, in a 2^3 factorial layout. The trial crop grown was English potatoes.

Table of Results—Yields in Tons per Acre

	Nitrogen	No Nitrogen	Mean
Phosphate	3·65	3·25	3·45
No Phosphate	1·87	1·78	1·82
Manure	3·59	3·27	3·43
No manure	1·93	1·75	1·84
Mean	2·76	2·51	2·63

	Manure	No manure	Mean
Phosphate	4·11	2·79	3·45
No Phosphate	2·75	0·89	1·82
Mean	3·43	1·84	2·63

L.S.D. at 1% level of t=0·79
L.S.D. at 5% level of t=0·57
} Between marginal means.

L.S.D. at 1% level of t=1·12
L.S.D. at 5% level of t=0·81
} Within body of table.

Significant increases were given to both phosphate and farmyard manure as shown above. No interaction reached significant level.

Grass Species and Manurial Exploratory Trial.—This trial was undertaken at Kianjokoma Farm in 1953 in order to gain more exact indications of the productivity of three grass species, and their establishment, in the area concerned.

Melinis minutiflora, Panicum maximum and *Pennisetum clandestinum* were compared with each other in combination with farmyard manure applied at 5 tons per acre versus nil, and double superphosphate applied at 2 cwt. per acre versus nil, in a 3^2 factorial layout with two replications only.

Two-way Table of Results

Mean Yields Per Acre in Tons of Unwilted Green Material

	Farmyard manure	Phosphate	Nil	Mean
Melinis minutiflora ..	29·2	24·3	19·7	24·4
Panicum maximum ..	21·9	19·9	14·4	18·7
Pennisetum clandestinum ..	22·9	21·4	21·1	21·8
Mean	24·7	21·8	18·4	21·6

The F test showed that no treatment difference reached significance.

The t test, however, gave the following *indication*:—

L.S.D., at 5 per cent level of t, between two marginal means=5.23.
L.S.D., at 5 per cent level of t, between two interaction means=6.18.

The general trend has been for *Pennisetum clandestinum* (Kikuyu grass) to catch up in productivity on the other two grasses following its much slower start in 1953.

(2) Star and Kikuyu Grass Zone

Bean Variety Trial.—This trial was carried out as a continuation of preceding trials in order to test the yields of various varieties of beans (*Phaseolus vulgaris*) during different seasons at Embu. A randomized block design with four replications compared the varieties: Kisola, Nziu, Syi Maa, Antwerp, Large White Kidney, Boston, Ndulya, Inyausi Ngau, No. III, Kibiti.

Table of Yields and Results

Variety	Total yield lb/acre	Difference from previous value
Nziu	1,635·0	
Kibiti	1,550·0	85·0
Boston (Control)	1,470·0	80·0
Antwerp	1,420·0	50·0
Ndulya	1,135·0	285·0
Inyausi Ngau	1,130·0	5·0
Kisola	1,130·0	0·0
Syi Maa	780·0	350·0
L.W. Kidney	760·0	20·0
No. III	660·0	100·0

L.S.D.=579·40 at 1% level of t.
L.S.D.=428·80 at 5% level of t.

This trial again confirms that Syi Maa is one of the lowest-yielding varieties of coloured beans during the long rains whilst being amongst the higher-yielding varieties of the short rains. Also, Large White Kidney, lowest yielding of the white haricots in the long rains is the highest yielding in the short rains.

There is no significant difference between the yields of the seven higher-yielding varieties.

Observational Trial on Field Infection of Haricot Beans by Bruchids.—This trial was a continuation of a similar experiment from 1953. Four half-acre plots of haricot beans were taken as control and four half-acre plots were treated twice with 5 per cent D.D.T. dust. The first application of dust was applied a month before harvesting and the second a fortnight before. Analysis of plot samples showed 0.1 per cent of the beans from treated plots to be Bruchid infested whilst 0.3 per cent of beans from untreated plots were infested. These figures confirm those obtained in 1953 and it is clear that at this low infestation rate dusting would not be economic.

Ridging, Mulching and Farmyard Manure Trial.—This experiment was undertaken at Embu Experimental Farm to study the effects of ridging, mulching and farmyard manure on the yield of maize and other crops. Three-foot ridges were compared with flat cultivation combined with mulching versus nil, and with five tons per acre of farmyard manure versus nil, in a 2^3 factorial layout with the interaction ridging, mulching, manuring confounded.

2 × 2 Tables of Means of Treatments

Yields in lb. of Maize Grain Per Acre

	Ridging	No ridging	Mean
Manure	6,393·60	5,794·80	6,094·00
No manure	5,300·00	4,962·40	5,131·20
Mulch	5,846·80	5,660·00	5,753·20
No mulch	5,847·20	6,097·20	5,472·00
Mean	5,847·20	5,378·40	5,612·80

	Mulch	No mulch	Mean
Manure	6,222·40	5,967·20	6,094·80
No manure	5,283·60	4,978·80	5,136·20
Mean	5,753·00	5,473·00	5,615·50

L.S.D. at 5% level = 468·80
L.S.D. at 1% level = 960·40
} Between marginal means.

L.S.D. at 5% level = 624·40
L.S.D. at 1% level = 855·20
} In body of table.

Significant increases were obtained to both ridging and manuring as shown above. The significant increase given to farmyard manure confirms results obtained in previous years. No significant increase has previously been given by ridging, but this result is probably attributable this year to very heavy rainfall when plots cultivated on the flat were apt to become waterlogged. No interaction reached significant level.

Exploratory Fertilizer Trial.—This experiment was started at Embu in 1952 in order to provide information as to the nutrient status of soils on the Embu experiment farm and on soils of a similar type in Central Province. Sulphate of ammonia applied at 0, 1, 2 cwt. per acre, double superphosphate applied 0, 1, 2 cwt. per acre, and muriate of potash applied at 0, ½, 1 cwt. per acre were combined in a 3^3 factorial layout, interaction N, P, K confounded. In 1954 double superphosphate was not reapplied to appropriate plots and the effect in this season was therefore residual only.

SUMMARY TABLES OF MEANS

Yields in lb. of Maize Grain Per Acre

	P0	P1	P2	K0	K1	K2	Mean
N0	4,687·86	5,332·80	5,433·46	5,134·49	5,332·80	4,986·83	5,151·37
N1	4,959·51	5,336·13	5,802·75	5,206·15	5,529·45	5,362·80	5,366·13
N2	4,866·18	5,552·78	5,682·76	5,556·11	5,162·82	5,382·79	5,367·24
Mean	4,837·78	5,407·24	5,639·66	5,298·92	5,341·69	5,244·14	5,294·91

	K0	K1	K2	Mean
P0	4,834·52	4,706·20	4,972·84	4,837·85
P1	5,409·46	5,429·46	5,382·79	5,407·24
P2	5,652·77	5,889·41	5,376·79	5,639·66
Mean ..	5,298·91	5,341·69	5,244·14	5,294·92

L.S.D. at 5% level of t=+ or − 366·80 lb.
L.S.D. at 1% level of t=+ or − 498·40 lb. } Between marginal means.

The response to the main effect of phosphate only, as indicated above, confirms the results obtained in preceding years.

Acknowledgments

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G. L. COULSON,
for Agricultural Officer (Experiments).

ANNUAL REPORT OF THE AGRICULTURAL OFFICER (EXPERIMENTS), NYANZA PROVINCE, 1954

Weather Conditions

Rainfall at experimental stations, 1954 (inches):—

	Kakamega	Bungoma	Kisumu	Kibos	Miwani	Kisii	Homa Bay	Sotik
January ..	1·08	0·68	0·81	1·93	2·26	2·26	0·66	1·83
February ..	1·22	2·29	2·48	2·54	4·58	2·46	0·21	2·15
March	1·07	3·59	1·38	3·85	5·19	4·90	1·36	2·05
April	7·27	9·39	8·21	11·95	6·43	13·46	11·12	14·33
May	15·94	11·72	7·32	10·73	8·27	11·57	9·73	8·10
June	6·57	4·73	1·62	2·84	3·55	6·75	3·30	4·39
July	7·63	5·03	3·78	5·56	4·94	2·83	2·93	2·65
August	6·38	5·10	4·47	5·01	5·75	5·65	5·52	1·74
September ..	5·82	4·86	2·36	2·07	2·73	9·38	3·99	1·81
October ..	4·02	5·61	1·58	2·83	2·21	3·99	4·74	2·96
November ..	2·06	2·72	0·32	1·50	1·42	1·94	2·56	4·19
December ..	4·50	6·68	4·93	3·74	5·61	6·65	3·73	3·95
Total ..	63·56	62·28	39·26	54·55	52·94	71·84	49·85	50·15

The long rains began at the beginning of April and were satisfactory and well distributed at most stations so that conditions for laying down experiments were mostly very favourable, although some experiments at Kisii and Homa Bay suffered from excessive wash and there was severe waterlogging at Kibos. Most stations had fairly adequate rain until September but the main short rains failed to materialize, October and November being unusually dry, but appreciable rain fell during December.

Reports on Experiments

Coffee Variety Trial, Kisii

This trial was planted in 1950 to test seven varieties of Arabica coffee. The design is a 7 × 7 latin square with nine trees per plot at 9 ft. × 9 ft. spacing on mulched box ridges without shade. The varieties are: Kitale 145, Thorolds, S.L. 14, Blue Mountain, S.L. 28, Kents and Kenya Selected. Yields were recorded for the first time in the 1953-4 season and these are shown below in lb. of cherry per acre.

Variety	lb. Cherry per acre
S.L. 14	1,063
S.L. 28	733
Kitale 145	568
Blue Mountain	472
Thorolds	458
Kents	322
Kenya Selected	287
Mean	558
Least significant difference (at P=0·05)	405

The general level of yield was very low as the crop was virtually a fly crop. The 1954-55 crop will be very much larger, but the results of this are not complete at the time of writing.

During 1954, the incidence of leaf rust—*Hemileia*—was heavy and the experiment was scored for this factor in August, each plot being given 3 marks for light "incidence" of rust, 2 for moderate "incidence" and 1 for heavy "incidence". The table below shows the mean score for each variety and least significant difference, although significance tests on arbitrary scores are of doubtful validity.

Variety	Mean score
Kents	2·14
Thorolds	2·00
Kenya Selected	2·00
Blue Mountain	1·85
S.L. 28	1·59
S.L. 14	1·14
Kitale 145	1·00
Mean	1·67
Least significant difference (at P=0·05)	0·56

Drainage and Phosphate Trials on Vlei Soils

At Sotik Post a small observational trial was laid down to compare the effect of three cultivation methods—flat, 3 ft. free draining ($\frac{1}{2}$ per cent grade) ridges and 6 ft. free draining ($\frac{1}{2}$ per cent grade) ridges on three crops—wheat, sorghum and wimbi, and two grasses—molasses grass and star grass. In addition the effect of 1 cwt. of double superphosphate per acre versus nil was tested on wheat and star grass and 3-ft. tie-ridging was tested on sorghum. A cut-off drain above the trial provided some degree of drainage for all the plots. During growth there was little or no visible difference in the growth of the three crops on the first three cultivation treatments but the two grasses grew better on the open-ridged treatment than on the flat. Sorghum on 3-ft. tie-ridges was a complete failure due to waterlogging. The wheat and star grass showed a visual response to phosphate, although damage by cockchafer bettles was slightly more severe on the phosphated than the unphosphated plots.

The yields of the three crops, which are given below suggest a possible advantage of 6 ft. ridging over 3 ft. ridging and flat cultivation, and a response to phosphate by wheat.

Lb. Dry Grain per Acre

	Flat	3-ft. ridges	6-ft. ridges	3-ft. tie-ridges
Wheat. P. ..	582	638	638	
Wheat. No P. ..			582	
Wimbi. P. ..	776	589	776	
Sorghum. P. ..	97	48	145	Nil

At Kaptarongei Estate, East Sotik, the proposed large scale drainage trial on 16 acres could not be started in 1954 owing to delay in obtaining a Cutherbertson drainer to construct the herring-bone drains which form one of the treatments. These were eventually constructed in November so that it should be possible to start the trial in 1955. The treatments are: herring-bone drains between ant hills, versus ridge and furrow system after levelling of ant hills, versus no drainage; phosphate versus nil. The intention is to plant half of the trial with various arable crops, the other half with a ley grass. In addition, on an adjacent nine acres of permanent grassland it is proposed to compare herring-bone drainage versus contour drains versus no drainage.

Exploratory Fertilizer Trials

Twenty-four of these small trials were planted on native *shambas* in the long rains of which 15 were in North Nyanza, 5 in the Kisii Highlands of South Nyanza and 4 in the Buret and Belgut divisions of Kericho. Except for some of the North Nyanza trials, all were in areas where little or no previous fertilizer work had been done. Maize was used as the test crop in all the trials and there were eight treatments consisting of all combinations of farm-yard manure at 5 tons per acre dug in before planting, double superphosphate at 1 cwt. per acre applied just before planting, in the planting lines, and sulphate of ammonia at 1 cwt. per acre applied 4 to 6 weeks after planting in a band six inches from each row. Plot size was 1/80 acre but had to be reduced to 1/160 acre at a few of the sites.

At the time of writing the results of the North Nyanza and Kericho trials are not complete, but the results of the Kisii Highlands trials are shown below, yields being in bags (200 lb.) of dry grain per acre:—

Site	Farmyard Manure		Double Superphosphate		Sulphate of Ammonia	
	With	Without	With	Without	With	Without
Matingas' . .	25·13	25·70	24·18	26·65	25·52	25·32
Kadomels'	17·56	16·08	18·72	14·92	17·67	16·40
Justus' . .	16·61	15·63	18·34	13·90	16·33	15·91
Gondianus'	19·12	14·63	16·69	17·07	16·66	17·09

The 5th site (Mororo) was unfortunately harvested by the owner but previous scorings during growth indicated a large phosphate response. The yield figures (shown above) for the other sites indicate a large phosphate response at Kadomels' and Justus', a large farmyard manue response at Gondianus', and a possible small response to sulphate of ammonia at Kadomels' only, these results being supported by scorings during growth.

Fertilizer Rates Trials

Two new fertilizer rates of application trials were started in 1954 at Kisii Farm and Kapkatet (Buret division, Kericho) in conjunction with the small exploratory trials in those areas. Double superphosphate and sulphate of ammonia were each applied to maize at four different rates of application, namely nil, $\frac{1}{2}$ cwt. 1 cwt. and $1\frac{1}{2}$ cwt. per acre. The phosphate was applied in the planting lines just before planting, the sulphate of ammonia in a band six inches from

each row some 4 to 6 weeks after planting. The design was a 4×4 factorial with 32 plots of 1/80 acre.

At the time of writing the results of the Kapkatet trial are not complete but the yield table below summarizes the results of the Kisii trial:—

KISII—BAGS OF DRY MAIZE GRAIN PER ACRE

DOUBLE SUPERPHOSPHATE		SULPHATE OF AMMONIA	
Rate	Yield	Rate	Yield
1½ cwt.	11·29	1½ cwt.	9·78
1 cwt.	9·97	1 cwt.	9·94
½ cwt.	9·54	½ cwt.	8·83
Nil	7·51	Nil	9·74
Mean	9·57		9·57
Least significant difference (at P=0·05)	2·01		2·01

There was a substantial response to phosphate, ½ cwt. per acre giving a significant increase in yield of two bags per acre but the additional increases given by the 1 and 1½ cwt. rates were not significant. There was no response to sulphate of ammonia and no interaction between the two fertilizers.

Tie-ridging Trial, Homa Bay (9/13/5)

This trial was started in 1952 to compare 3-ft. tie-ridging, 5-ft. tie-ridging and flat cultivation on a series of crops over several seasons. The design was four randomized blocks with plot size 1/10.4 acre and plots split for F.Y.M. and phosphate treatments in the first year. Cotton was the crop in 1953-54, harvested too late for inclusion of the results in the 1953 annual report. Rainfall during the period was rather above average. The table below shows the yields of cotton for the three cultivation treatments:—

LB. OF SEED COTTON PER ACRE, 1953–54

Treatment	Yield
3 ft. tie-ridging	426·40
5 ft. tie-ridging	391·35
Flat	318·55
Mean	378·77
Least sig. difference (P=0·05) ..	53·66
Least sig. difference (P=0·01) ..	81·33

3-ft. and 5-ft. tie-ridging both resulted in a highly significant increase in yield of seed cotton over flat cultivation but difference between the two types of tie-ridging was not significant. There was no significant residual effect of the 1952 F.Y.M. and phosphate applications and no significant interaction.

The 1954 crop was groundnuts. Rainfall during the growing period was about average and better distributed than usual. 3-ft. and 5-ft. tie-ridging yielded practically the same and both yielded significantly better than the flat, as shown in the yield table below:—

LB. OF DRIED, UNSHELLED GROUNDNUTS PER ACRE, 1954

Treatment	Yield
3-ft. tie-ridging	2,831·9
5-ft. tie-ridging	2,812·2
Flat	2,427·4
Mean	2,690·5
Least sig. difference (at P=0·05)	335·9

The trial will be concluded in 1955 with a crop of maize. The evidence to date supports the practice of tie-ridging with the common field crops at Homa Bay but the economics of the practice have not been studied there.

Tie-ridging Trials, Kakamega and Kisii

These trials which were started in the long rains 1953 (*see* 1953 annual report) were continued in the short rains 1953 and the long rains 1954. The design was 5×5 latin square with plot size 1/48 acre and treatments: flat cultivation versus 3-ft. tie-ridging versus 5-ft. tie-ridging, each of the latter two main treatments containing the comparison: splitting and remaking of ridges each season versus moulding up of ridges each season, thus making five treatments altogether. This latter comparison was, however, not applied since the weed problem in these high rainfall areas made the moulding-up treatment impracticable.

The short rains 1953 crop at Kakamega was simsim which gave a very low overall yield. The standard error was high and there were no significant treatment differences although both types of tie-ridging gave a small increase in yield over flat cultivation and 5-ft. tie-ridging yielded slightly more than 3-ft. tie-ridging. At Kisii with a crop of green gram, which also gave a very low level of yield and a high standard error, the flat treatment yielded more than the 3-ft. tie-ridging which outyielded the 5-ft. tie-ridging, but these differences were not significant. The yield data are given below:—

SHORT RAINS, 1953

	Kakamega lb. dry sesame/acre	Kisii lb. dry green gram/acre
Flat	145·2	421·1
3 ft. tie-ridging	208·1	282·2
5 ft. tie-ridging	237·2	210·5
Mean	196·8	304·6
Least significant difference (at P=0·05)	199·4	319·4

In the long rains 1954 the crop at Kakamega was maize. The level of yield was high and there were no significant differences between treatments although the flat yielded slightly more than the 3-ft. and 5-ft tie-ridging which gave almost the same yield. A record was kept of the amount of hand labour used to prepare the various plots for planting, planting and after-cultivation during growth. This data is shown in the second table below and should be regarded as comparative not absolute. It will be seen that the tie-ridged plots required nearly twice as many man hours as the flat plots for these operations.

KAKAMEGA—BAGS DRY GRAIN/ACRE—LONG RAINS, 1954

Treatment	Yield
Flat	20·60
3 ft. tie-ridging	19·35
5 ft. tie-ridging	19·30
Mean	19·75
Least significant difference (P=0·05).	2·74

MAN-HOURS PER PLOT (1/40 ACRE)

	Flat	3 ft. t.r.	5 ft. t.r.
22–2–54 1st hand preparation ..	2·20	4·80	5·00
8–4–54 2nd hand preparation ..	2·00	4·70	4·70
8–4–54 planting	0·20	0·17	0·15
27–5–54 after-cultivation	2·97	3·10	3·00
Total	7·37	12·77	12·85

At Kisii the long rains 1954 crop was sorghum which suffered so severely from wash and constant breaking of the tie-ridges that it had to be abandoned.

These trials will not be continued in 1955 since it is already evident under the high rainfall conditions of Kakamega and Kisii that there is no yield advantage of tie-ridging and the labour requirements have been shown to be much higher than for flat cultivation.

Farmyard Manure and Phosphate Trial

This trial which was started at Kakamega and Kisii in 1953 was continued in the long rains 1954 at Kakamega and in the short rains 1953 and long rains 1954 at Kisii. The design was a $3 \times 3 \times 3$ factorial with plot size 1/40 acre and the following treatments:—

(*a*) Farmyard manure at nil, 2½ and 10 tons per acre.

(*b*) Double superphosphate at nil, ½ cwt. and 1 cwt. per acre.

(*c*) Three repetitive treatments.

At Kakamega maize was planted in the long rains 1954 without any repetitive treatments so that it merely measured residual effects of the 1953 farmyard manure and phosphate applications. The yields of maize showed a

small but non-significant residual effect of the 10-ton rate of farmyard manure but no residual effect of the phosphate and no significant interaction:—

KAKAMEGA—LONG RAINS, 1954—BAGS DRY MAIZE PER ACRE

Farmyard Manure	Yields	Double Supers	Yields
10 tons/acre	17·56	1 cwt./acre	17·02
2½ tons/acre	16·82	½ cwt./acre	16·89
Nil	16·78	Nil	17·26
Mean	17·05		17·05
Least significant difference (P=0·05)	1·89		1·89

At Kisii a ratoon crop of sorghum was taken in the short rains 1953 to measure residual effects. The level of yields was very low but they showed an appreciable residual effect of the 10-ton rate of farmyard manure and possibly of the 1-cwt. rate double superphosphate. There was no significant interaction.

KISII—SHORT RAINS, 1953—BAGS DRY SORGHUM PER ACRE

Farmyard Manure	Yields	Double Supers	Yields
10 tons/acre	2·45	1 cwt./acre	2·31
2½ tons/acre	1·94	½ cwt./acre	1·76
Nil	1·75	Nil	2·07
Mean	2·05		2·05
Least significant difference (P=0·05)	0·35		0·35

In the long rains 1954 at Kisii repetitive treatments were applied on appropriate plots as follows: nil; farmyard manure at five tons per acre; double superphosphate at ½ cwt. per acre. The crop was wimbi. Of these repetitive treatments there was a non-significant response to the farmyard manure and a much larger and significant response to the phosphate. Of the treatments applied in the long rains 1953 there appeared to be a residual effect of the 2½ and 10-ton rates of F.Y.M. and of the 1-cwt. rate of double supers but these effects were not significant. There were no significant interactions.

KISII—LONG RAINS, 1954—BAGS DRY WIMBI PER ACRE

1953 F.Y.M.	Yields	1953 Double Supers	Yields	1954 Repetitive treatments	Yields
10 tons/acre ..	5·40	1 cwt./acre ..	5·92	F.Y.M. 5 tons/acre ..	5·00
2½ tons/acre ..	5·64	½ cwt./acre ..	5·06	D. Supers ½ cwt./acre ..	6·32
Nil	4·89	Nil	4·96	Nil	4·62
Mean	5·31		5·31		5·31
Least sig. diff. (at (P=0·05)	1·56		1·56		1·56

Compost Trial, Kakamega

This unofficial trial was started in 1953 to test the effect on maize of Kakamega township compost at five rates of application in a 5 × 5 latin square with plot size 1/40 acre. During 1954 residual effects were measured on maize, yields of which were as follows:—

BAGS DRY MAIZE GRAIN PER ACRE

Treatments	Yield
Compost (in 1953) at 40 tons/acre	21·73
Compost (in 1953) at 30 tons/acre	19·92
Compost (in 1953) at 20 tons/acre	19·89
Compost (in 1953) at 10 tons/acre	19·48
Nil	18·30
Mean	19·87
Least significant difference (at P=0·05) ..	4·38

There is a small progressive residual effect of the compost but it is not statistically significant.

Fodder Crop Observation plots

These plots were all planted in the long rains 1954 to test various potential fodder crops at sites representative of the principal ecological zones in the province. The sites were:—

Kisii	Kikuyu/Star grass zone.
Kakamega	Star grass zone.
Bungoma	High rainfall savannah.
Kibos	Kano Plains.
Rabuor	Kano Plains.
Ahero	Kano Plains.
Paponditi	Kano Plains.
Homa Bay	Lake shore savannah.

The fodder crops included at each of these sites were: Uganda hairless Napier grass; improved perennial Kavirondo sorghum; fodder cane M.F. 2/40; *Beckeropsis uniseta*: *Dolichos* sp. ex Kilima Kiu. In addition at Kakamega only, two other varieties of Napier grass from the Cameroons and the Gold Coast respectively were tried, while at Kibos "Muthigwa" sorghum (ex Kitui) was included. Various subsidiary treatments were tested. The effect of farmyard manure, phosphate and sulphate of ammonia was tested at Kisii, Kakamega and Bungoma; farmyard manure and tie-ridging at Homa Bay and Kibos, tie-ridging at Rabuor, Ahero and Paponditi. These treatments were not replicated. Plot size was 1/300 acre in most cases. During the year each plot was cut and weighed as far as possible whenever the optimum stage for fodder was reached although some cuts were taken well before this stage. The following is a summary of the results for the year: Napier grass (Uganda Hairless) has given much higher yields than any of the other fodders at all sites except Paponditi on very poor soil where it gave very low yields and has so far been outyielded by improved perennial Kavirondo Sorghum. It has shown very large responses to F.Y.M. at Kisii, Kakamega and Bungoma but only small responses at Kibos and Homa Bay. At Kakamega and Bungoma it responded well to phosphate and there was also a nitrogen response at Bungoma. At Rabuor, Ahero and Paponditi on the Kano Plains, tie-ridging produced far higher yields than flat cultivation but has

so far shown little or no benefit at Kibos and Homa Bay. Napier grass ex Cameroons and ex Gold Coast at Kakamega have given similar yields to the Uganda hairless variety but it is too early yet to comment on their potentialities.

Improved perennial Kavirondo sorghum has given much lower yields than Napier grass at all sites except Paponditi. On all the Kano Plains plots it appears to remain green into the dry season better than Napier grass. At Kisii it has made very slow growth on account of cold wet conditions. At Kakamega it gave a small response to phosphate but little or none to nitrogen or F.Y.M. At Rabuor and Paponditi tie-ridging gave much higher yields than flat cultivation but not at Ahero. "Muthigwa" sorghum at Kibos appears to be much more leafy than improved perennial Kavirondo sorghum but it remains to be seen whether it will behave as a perennial. At Homa Bay ordinary local sorghum planted in the short rains after long rains beans gave a very high yield (actual yield not recorded) of green material for silage in mid-October and should give a second cut in January, 1955.

Fodder cane M.F. 2/40 has made comparatively slow growth at Kakamega, Kibos and the Kano Plains plots. At Kisii it has not yet given a cut, while at Homa Bay and Bungoma establishment was very poor due to termite attack. It is probably not worth further trial.

Beckeropsis uniseta.—At Kakamega (where it is indigenous) this has given a higher yield than improved perennial Kavirondo sorghum and is more palatable. It has responded well to phosphate and nitrogen, and is easily established from seed. At Kisii and Kibos however it has given very low yields.

Blue Lupin.—A small plot at Kakamega gave a yield of 11.29 tons per acre.

Dolichos ex Kilima Kiu.—Preliminary observation plots of this legume show that it should do well over most of Nyanza (except in the highest altitude areas) in admixture with Napier grass. It has been found that (unlike at Kitale) the Napier grass must be established *before* sowing the *Dolichos* to prevent it being smothered by the latter.

Ley Species Observation Plots

These small plots were planted in the long rains at numerous sites in the main ecological zones of the province to obtain further information on species suitable for each zone. The sites and their respective ecological zones were as follows:—

Sotik	Kikuyu/Star grass zone.
Kisii	Kikuyu/Star grass zone.
Kakamega	Star grass zone.
Bungoma	High rainfall savannah.
Lambwe Valley	High rainfall savannah.
Rabuor	Kano Plains.
Homa Bay	Lake shore savannah.
Ahero	Kano Plains.
Paponditi	Kano Plains.
Sotik Post	Sotik vlei.
Cheleget	Masai grassland.

At each site a selection of the following grasses was planted: Molasses grass, Nzoia Rhodes, Rongai Rhodes, *Paspalum dilatatum*, Nandi *Setaria*, *Cenchrus ciliaris*, *Panicum maximum* var. trichoglume, *Paspalum scorbiculatum*, Star grass, *Panicum makari-kariensis*, Pemba grass and Kikuyu grass. At Kisii, Kakamega and Bungoma subsidiary treatments were applied to test the effect of farmyard manure, phosphate and sulphate of ammonia. Plot size in most cases was 1/300 acre. During the year plots were cut and weighed as far as possible whenever

the optimum grazing stage was reached. These yield records for the year are not complete at the time of writing but a few outstanding observations may be mentioned here: at Kakamega, Kisii, Bungoma and Sotik the establishment from seed of Molasses, Rhodes, and Nandi *Setaria* normally presents little difficulty but *Paspalum dilatatum* is often slower although it usually forms a good stand in the year after sowing.

At Homa Bay and in the Lambwe Valley great difficulty has so far been experienced in getting any of the grasses to germinate from seed so that for these areas it is still only possible to recommend vegetatively-planted grasses of which the best at present are Star grass and *Panicum makari-kariensis.*

On the Kano Plains plots very good germination and establishment of seeded gresses was obtained this year. In the yield cuts Rongai Rhodes, Nzoia Rhodes and *Cenchrus ciliaris* were the highest yielding of the seeded grasses and remained comparatively green in dry weather, but the highest yields of all were given by vegetatively-planted *Panicum makari-kariensis.* Molasses grass, *Paspalum dilatatum* and Nandi *Setaria* gave comparatively low yields and it is doubtful if the latter two will survive the dry season.

At Sotik Post *Paspalum scorbiculatum* and *Panicum makari-kariensis* at present show some promise for use on the vlei.

At Cheleget all the seeded grasses established extremely well and gave high yields, but it is suspected that the plots were sited in an area of higher fertility than most of this zone and a dry season has not yet been experienced. The highest yields were given by Rongai Rhodes, followed by Nandi *Setaria.*

Molasses Grass Establishment Trial, Kakamega

This trial was started in 1952 at Kakamega to study the effect of various treatments on the establishment of a Molasses grass ley under a maize nurse crop. Results up to the end of that year were contained in the 1952 Annual Report. During 1953 and 1954, the field was grazed normally and a series of production cuts taken on each plot with an auto-scythe, the area cut in each plot being 1/484 acre. It was not possible to make a cut at every grazing period and therefore the cuts are not a measure of the total production but do provide a direct comparison of the effects of the various establishment treatments on the productivity and on the persistence of the molasses grass, the later being separated and weighed separately from other species in the herbage. Treatment yields in tons per acre of molasses grass are shown in Table I, and the comparative yields of molasses grass and of other species in the herbage are shown in Table II.

TABLE I.—TREATMENT YIELDS (TONS/ACRE OF MOLASSES GRASS)

Date of cut	E	L	D	B	N	C	P	O
24–6–53 ..	3·57	3·41	3·88	3·09	3·55	3·43	3·54	3·44
9–9–53 ..	1·92	1·69	1·95	1·66	1·76	1·85	1·85	1·76
5–1–54 ..	1·56	1·71	1·90	1·37	1·60	1·67	1·59	1·68
	7·05	6·81	7·73	6·12	6·91	6·97	6·98	6·88

E="Early" sowing of molasses grass (early May when maize 1 ft. high).
L="Late" sowing of molasses grass (early June when maize 3 ft. high).
D=Drilling (in rows) molasses grass.
B=Broadcasting of molasses grass.
N="Normal" spacing of maize nurse crop (4 ft by 1 ft.).
C="Close" spacing of maize nurse crop (2½ ft. by 9 in.).
P=Double superphosphate at 1 cwt./acre.
O=No Double superphosphate.

TABLE II.—COMPARATIVE YIELDS OF MOLASSES GRASS AND OF OTHER SPECIES

Date of cut	Mean yield of molasses grass	Mean yield of other species	Per cent by weight of other species in total cut
	(*lb.*)	(*lb.*)	*per cent*
24–6–53	3·44	0·16	4·4
9–9–53	1·81	0·70	27·9
5–1–54	1·68	1·07	38·9

The following conclusions are drawn from this data:—

(1) Drilling the molasses grass seed in rows resulted in appreciably higher yields of grass at all three cuts compared with broadcasting.

(2) Early May sowing of molasses grass and application of phosphate both resulted in slightly higher yields at the first two cuts compared with early June sowing and with no phosphate respectively.

(3) There was no difference in grass yield between the two spacings of the maize nurse crop. In view, however, of other observations, both at Kakamega and elsewhere on wider spacings, this point requires further investigation.

(4) There was a steady encroachment of other species (both grasses and dicotyledons) into the sward. By mid-1954 (two years from planting) it was estimated that molasses grass composed less than 50 per cent of the sward. This is confirmed by other observations at Kakamega which show that molasses grass there does not persist longer than two to three years from planting.

Star Grass Grazing Trial, Kakamega

This observational trial was started in 1953 to compare the effect of four different predetermined stocking rates on the productivity (carrying capacity) of an old predominantly Star grass pasture. The field was divided into four half-acre paddocks which were stocked respectively at 2, 4, 6, and 8 beasts (or 4, 8, 12 and 16 beasts per acre) the cattle being put into and taken out of their respective paddocks as dictated by the state of the grass, according to normal farm alternate grazing practice.

The trial was commenced at the end of April, 1953, and concluded in August, 1954, when the field was due for breaking. The results for each year and for the whole period of the trial are shown below:—

CARRYING CAPACITY (BEASTS PER ACRE)

Paddock	A	B	C	D
No. of beasts (per paddock) ..	2	4	6	8
1953 carrying capacity	1·43	1·80	2·16	2·51
1954 carrying capacity	1·48	1·52	1·88	1·64
1953 and 1954 carrying capacity ..	1·45	1·68	2·04	2·11

These figures show that there was a progressive increase in carrying capacity with increasing stocking rate from two to eight beasts per half-acre paddock, although in 1954, the eight-beast paddock gave a slightly lower carrying capacity

than the six-beast paddock. It is concluded that within the range of stocking rates used, a high stocking rate (i.e. grazing down each flush comparatively rapidly with numerous beasts) results in higher productivity (carrying capacity) in a predominantly Star grass pasture at Kakamega than a comparatively low stocking rate. This result provides support for the practice of strip grazing on the Kakamega farm.

The trial confirms previous results that the carrying capacity of this type of pasture at Kakamega is between $1\frac{1}{2}$ and $2\frac{1}{2}$ beasts per acre.

Groundnut Observation Plots, Kibos

Seventy-five varieties of groundnuts were grown in very small unreplicated plots (1/363 acre) at Kibos in the long rains. 3 ft. × 2 ft. spacing on tie-ridges was used. Of these varieties 49 were obtained from the Empire Cotton Growing Corporation, Nyasaland, the remaining 26 were local Nyanza types. Observations were made on each variety for habit of growth, incidence of *Cercospora* leaf spot and colour of nut. The number of days to maturity and the yield of each variety were also recorded. There was practically no incidence of "Rosette" disease. The variation in yield was from 182 to 1,361 lb. of shelled nuts per acre. The latter yield was given by an extreme bunch variety SA/A-5=42-G-105 and by an unnamed Nyanza variety. These and the other most promising varieties will be tested in a statistical variety trial in 1955.

Potato Variety Trial, Kisii

This trial was done in the long rains 1954, to compare the yield of five potato varieties obtained from Mr. Nightingale, Kinangop, with a local Kisii variety ("Local Nyangusu"). The design was a 6 × 6 latin square, plot size 1/80 acre and spacing 30 in. × 15 in. on ridges.

The growing period was from 29th April, to 20th August, a period of fairly well distributed rain which amounted to about 26 inches. Varieties remained free of "blight" attack except for a slight attack on the local variety. The varieties A. 49, Dutch Robjyn and Local Nyangusu gave a significantly higher yield than D. 49, M. 49 and Kerrs Pink as shown in the table below:—

YIELDS OF FRESH TUBERS

Variety	tons per acre
A.49	3·56
Dutch Robjyn	3·49
Local Nyangusu	3·11
D.49	2·45
M.49	2·26
Kerr's Pink	2·20
Mean	2·85
Least significant difference (at P=0·05)	0·62

Rice Observation Plots, Namasaria

Work on rice at the Namasaria plots near Kisumu in 1954 was confined to an unreplicated variety trial of nine varieties, and an observational trial on direct seeding of rice in rows in the field for comparison with the normal method of transplanting from a seedbed.

The variety trial consisted of a single plot of each variety, plot size varying 1/20 to 1/50 acre depending on the number of seedlings available. Spacing of the seedlings was 9 in. × 9 in. with three seedlings per hole. Transplanting was done in early April and harvesting during August after a growing period of 4 to 4½ months.

The supply of irrigation water was very satisfactory during most of the growing period and the general level of yield was high.

GROWING PERIOD AND YIELD OF VARIETIES

Variety	Growing period	Yield of Dry Paddy per Acre	
	days	*lb.*	*bags*
Ambarikore	126	4,396	27·47
Rathkayaral 3753	122	4,008	25·05
Faya..	124	3,791	23·69
Sindano	124	3,738	23·36
Bungala	126	3,650	22·81
Afaa (Mwanza)	136	3,421	21·38
Senna	122	3,221	20·13
Maji Maji	123	2,931	18·32
Pishori	122	2,871	17·94
Mean	125	3,558	22·24

Considering these results together wih those obtained in previous variety trials at Namasaria and Ragumo on the Kano Plains since 1949, the following varieties have consistently given the highest yields in seasons of adequate irrigation water: Rathkayaral 3753, Ambarikore and Sindano. During the three seasons of adequate irrigation water—1951, 1952 and 1954 these varieties each yielded between 20 and 30 bags of paddy per acre each season, and they are all white grained varieties of good milling quality. The variety Mbuyu is probably in the same class although it was not included in the 1954 trial. The varieties Faya, Maji Maji and Bungala are also very high yielding but are red grained varieties of lower milling quality. Bungala in particular has a very bad milling reputation.

Sorghum Observation Plots

One hundred and seventy-five varieties of sorghum were grown at Kibos and Kakamega in the long rains in very small unreplicated plots. 111 of the varieties were those grown at Kibos in 1953 and the remaining 64 consisted of 45 received from Makueni (Southern Province) and a further 19 Nyanza types. The trial at Kakamega was virtually a failure due to waterlogging after planting resulting in very uneven germination, and to wet conditions at ripening time which caused very severe damage from head mildew, covered smut and ergot disease.

At Kibos germination was also very uneven due to waterlogging but observations were made on each variety for tillering, height, head density, grain colour, pests and diseases. The time to maturity and yield were also recorded. Nine varieties were picked out for testing in a statistical variety trial in 1955. One of these—Dobbs, was grown at several sites on the Kano Plains in 1954. Compared with the local tall red grained type it was much more resistant to lodging, was earlier maturing and gave an appreciably higher yield. Four varieties were picked out for their leafiness for inclusion in fodder trials in 1955.

Sugar Variety Trials, Miwani-Kibos Area

The trial on Kala Singh's farm, Kibos (29/2/2) which was started in 1950 and had its plant crop harvest in 1952 was harvested again (1st ratoon) in early April, 1954. Yields are shown in the table below:—

1st Ratoon—Tons of Cane per Acre

Variety	Yield
CO.331	33·42
CO.434	28·23
CO.213	25·07
B.3337	24·80
CO.281	22·26
CO.417	19·76
CO.408	19·64
CO.419	19·41
CO.285	19·35
CO.421	18·93
M.F.2/40	17·37
CO.432	16·25
POJ.2747	15·95
CO.244	13·16
B.3257	11·15
POJ.2714	10·37
Mean	19·69
Least significant difference (P=0·05) ..	5·63

Compared with the plant crop, all the varieties gave a much reduced yield, this reduction being roughly 50 per cent. This was probably partly due to the effects of drought in the severe dry season of 1952-53, and a further contributory factor may have been the presence of "Ratoon stunting disease" which was definately confirmed in some of the varieties in March, 1954. The varieties CO.331, CO.213, and CO.434 again did well but CO.419, CO.408 and CO.421 which did well in the plant crop harvest, dropped to about half-way down the list, while B.3337 and CO.281 did comparatively better than at the plant crop harvest, CO.281 coming through the 1952 53 drought better than many other varieties.

The variety trial of five varieties at Miwani (29/2/5) had its plant crop harvest in 1954. This trial was planted on both the upper and lower soils at Miwani and contained five promising varieties picked out from the Kala Singh Variety trial (29/2/2) after the plant crop harvest of the latter. The design was a 5 × 5 Latin square with plot size 1/24.7 acre and spacing 6 ft. × 2 ft. on 6-ft. ridges. Yields of cane were as follows:—

Plant Crop—Tons of Cane per Acre

Variety	Upper soil	Lower soil
CO.331	37·88	47·43
CO.213	32·44	58·29
CO.408	29·51	53·51
CO.421	25·22	35·62
CO.419	22·36	41·48
Mean	29·48	47·27
Least significant difference (at P=0·05)	2·67	12·10

These results provide further evidence that the varieties CO.331, CO.213 and CO.408 are higher yielding at Miwani than CO.421, the main commercial variety. CO.408, however, is rather prone to lodging which would probably rule it out for mechanical harvesting.

Sugar Variety Trial, E. Konyango

This trial was planted in October, 1952, to compare five varieties and to assess the potentialities of the crop in an impeded drainage area of South Nyanza where cane growing by Africans was being started. The varieties were CO.421, CO.419, CO.408, CO.213 and CO.331. The design was a 5 × 5 Latin square with plot size 1/170 acre and spacing 4 ft. × 2 ft. on the flat. The dry season after planting unfortunately resulted in very uneven establishment but those stools which did establish subsequently grew extremely well and at the plant crop harvest in November, 1954, the overall yield of cane was 48.2 tons per acre and the yield of tops 10.9 tons per acre. Although no valid yield comparison was possible between varieties, observations were made on height of cane, diameter, length of middle internode, lodging and disease. These observations suggested that CO.421, CO.419 and CO.331 are likely to be more suitable varieties for the area than CO.213 or CO.408. As regards time of planting and drainage in this area, long rains planting of cane is probably preferable to short rains planting providing there is drainage. The indications so far from a nearby observational drainage trial and from Native cane *shambas* in the vicinity suggest that a comparatively limited degree of drainage such as a simple ridge and furrow system may well be sufficient.

Sugar Cane Fertilizer Trial, Miwani

This trial was laid down in 1952, to test the effect of sulphate of ammonia, double superphosphate and muriate of potash on the yield of sugar cane. The design was a 3 × 3 × 3 factorial with plot size 1/20 acre and cane spacing 6 ft. × 2 ft. on 6 ft. ridges. The treatments were:—

(*a*) Sulphate of ammonia at nil, 3 cwt. and 6 cwt. per acre.

(*b*) Double superphosphate at nil, 1 cwt. and 2 cwt. per acre.

(*c*) Muriate of potash at nil, 1¼ cwt. and 2½ cwt. per acre.

The phosphate was applied in the planting holes before planting, the sulphate of ammonia and potash about six weeks after planting, in shallow drills 6 in. from and on each side of the cane rows.

No visual differences between treatments could be detected during growth. The trial was harvested (plant crop) in 1954. There were no significant treatment effects or interactions, although the yields suggest a possible small response to sulphate of ammonia and to muriate of potash.

The fertilizers were re-applied to the 1st ratoon crop at the same rates as before.

Sugar Cane Herbicide Trial, Miwani

In co-operation with Messrs African Explosives and Chemicals Limited, this trial was started at Miwani in September, 1952, to test the effect of various chemical herbicides on weed control in newly planted cane. The design was a 6 × 6 Latin square with plot size 1/40 acre and the treatments were as follows:—

(*a*) Control.

(*b*) "Agroxone 3", two pre-emergence (weeds) applications at 6.4 pints per acre.

(*c*) Y.F. 2758, two pre-emergence (weeds) applications at $\frac{1}{3}$ gallon per acre.

(*d*) "Agroxone 3", one pre-emergence (weeds) application at 6.4 pints per acre, plus one post-emergence (weeds) application of Kanex (Penta-chlor-phenol at 2 gallons, diesel oil at 3 gallons and Y.F. 2758 at $\frac{1}{3}$ gallon per acre.

(*e*) T.C.A. (Tri-chlor-acetate), two pre-emergence (weeds) applications at 10 lb. per acre.

(*f*) One post-emergence application of "Agroxone 3" at 6.4 pints, "Kanex" at 2 gallons and diesel oil at 3 gallons per acre.

The trial was concluded with the harvest of the cane in July, 1954. The results may be summarized as follows:—

(1) T.C.A. in 2 pre-emergence applications, gave good control of grass weeds but not of broad-leaved weeds.

(2) "Agroxone 3" in 2 pre-emergence applications, gave good control of broad-leaved weeds but not of grasses, probably partly due to the applications being too late after many weeds had in fact emerged.

(3) "Kanex" in a post-emergent application appeared to have very little effect.

(4) The practical effect of the herbicide treatments was probably to save one mechanical weeding and one hand weeding, valued together at sh. 20/50 per acre. This saving does not approach the cost of the chemicals used. Several of the treatments however gave an appreciably higher yield of cane than adjacent estate cane planted at the same time, but this is not a valid comparison and a proper measure of the economics of chemical weed control could probably only be obtained by actual costings on large estate blocks.

L. J. COLLINGS-WELLS,
Agricultural Officer (Experiments)
(Nyanza Province).

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